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DEMONSTRATION OF THE MAGNETIC FIELD OF A DYNAMO AND THE EFFECT OF ARMATURE CURRENT ON THIS FIELD.

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The apparatus described below has proven serviceable in the laboratories at Pratt Institute to demonstrate the magnetic field in dynamos and study the modifications of this field that are produced by armature current.

The student may know the fact that the brushes of a dynamo must be given a "lead" to prevent excessive sparking; he can hardly appreciate the underlying reason and the dependence upon the modification of the field by the superimposed field due to the armature current unless he has seen the actual effect produced.

In the plan here described the student may study the bi-polar or the multi-polar model shown in figures I and II, or both as desired.

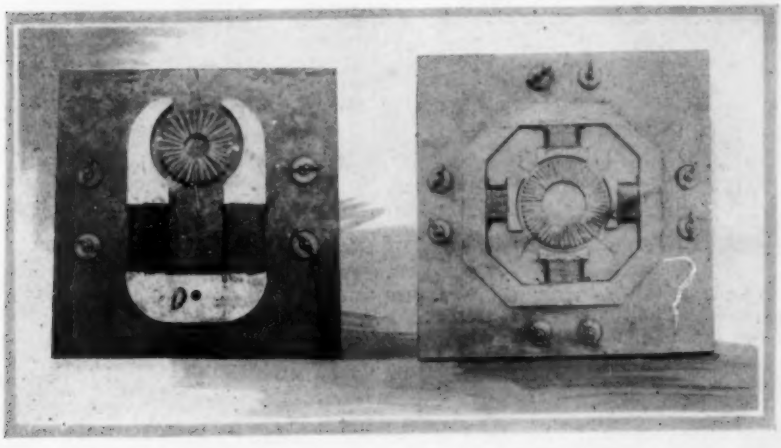

FIG. I. FIG. II.

The bi-polar field is built up of fourteen laminations such as are used in the CQ ¼ H. P. motor manufactured by the G. E. Co., or may be cut from No. 30 sheet steel, these are riveted together, having pieces of ⅛ inch thick soft sheet-steel on each flat surface of the pole-pieces, AA, and the yoke, D, but none on the poles, BB. The model four-pole dynamo field is constructed of fourteen eleven inch square pieces of No. 30 soft sheet steel faced on each flat surface with a piece of ⅛ inch soft sheet steel and rivited together, then milled to shape as in figure II.

Overwound on the poles, BB, are the field coils of one layer of No. 18 D. C. covered copper wire. Both ends of each coil are brought out to separate binding posts, X′X′, etc.

A soft steel ring, EF, placed between the pole-pieces as shown in figures I and II, replaces the armature. This is overwound with one layer of No. 18 D. C. covered copper wire as shown in figure III. Wound in this way each turn is equivalent to a coil on a ring wound armature and all the turns on side EGF are in series and those on side EHF are also in series while EGF and EHF are in parallel with one another. Applying the thumb rule we see that each half of the armature tends to set up a polarity at E and the opposite polarity at F. Thus all the effects that are common in direct current dynamo operation are produced.

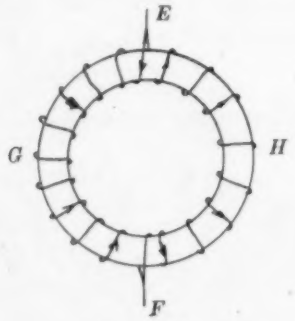

FIG. III.

Maps of the magnetic fields are made by placing a sheet of thin cardboard or glass over the apparatus and lightly sprinkling iron filings evenly over it in the usual manner.

By using a lamp-bank, or other suitable resistance, in series with the coils these coils may be used on 110 volt circuits and will carry without undue heating about six amperes.

The first direction for the student is to determine the correct

connection to give the proper polarity of the field poles. This is especially helpful in teaching the thumb-rule of flux and current relation. In connecting the four-pole field, many errors are possible and almost invariably the student's first connection is wrong. With a small compass, or by mapping the field, he at once may determine the trouble. Studying to determine the cause of error does much to fix the thumb-rule and the idea that like poles repel and unlike poles attract as well as to bring out the arrangement of poles and flux paths in a dynamo circuit.

The clearest method of attacking the problem is to divide it into three steps: (a) The magnetic field which results from exciting field alone; (b) Magnetic field of armature ring alone when carrying current, and (c) Resultant field when field of (b)

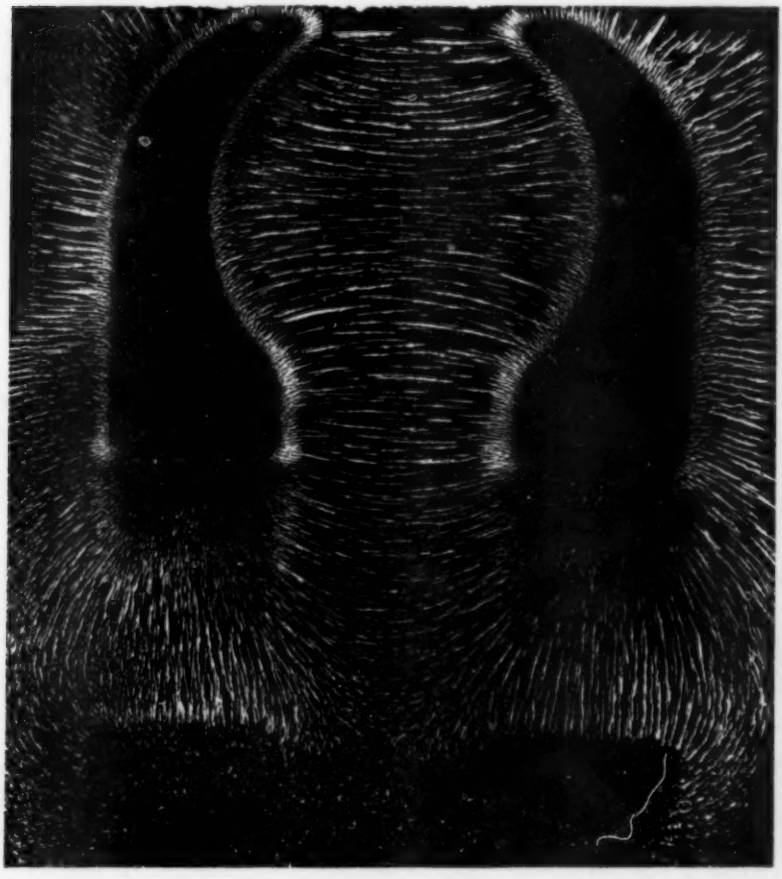

FIG. IV.

is superimposed on field (a). This brings out forcibly the distortion of magnetic flux paths by armature current which is the final conception the student needs to get.

To obtain the characteristic field of (a) the student, having made proper connections, and with current flowing in the exciting coils and with no armature in the magnetic circuit, should notice that much of the flux takes a straight path from pole piece to pole piece but that there is much leakage. Sample field Fig. IV.

Next by placing the armature (carrying no current) in the magnetic circuit we obtain results as in figure V. The polarity of the poles is as shown. Most of the flux, emerging from the North pole-piece, crosses the air-gap along the shortest path, or radially to the armature-ring and threads through the interior of the iron finally crossing the second air-gap to the South pole-

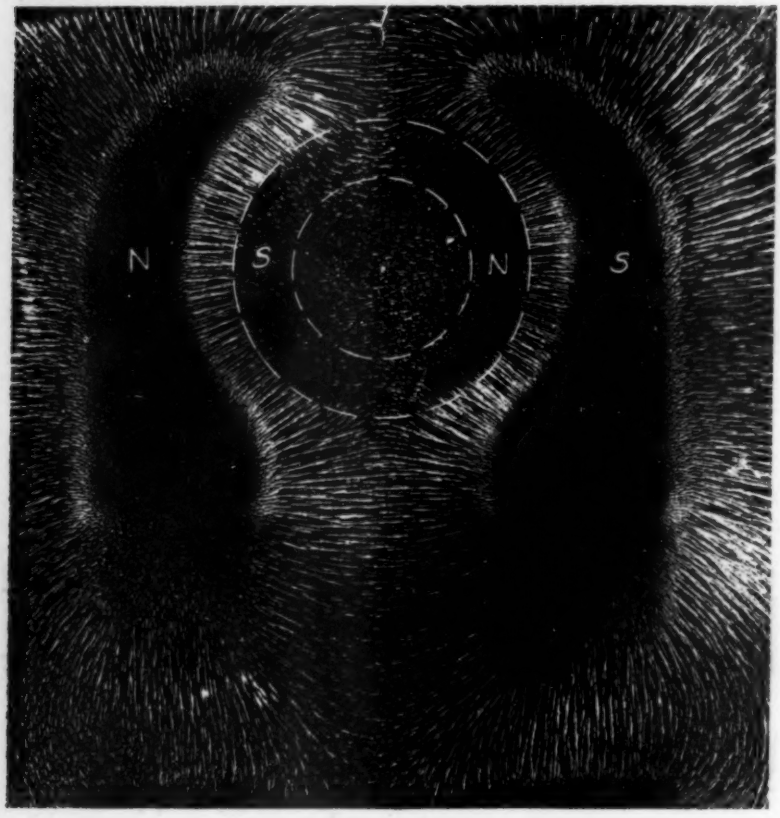

FIG. V.

piece and from there through the poles and yoke back to the North pole-piece thus completing the magnetic circuit. The portion of the ring towards the North pole-piece is of induced South polarity, and similarly that before the South pole-piece is of induced North polarity. When entirely within the iron, the flux does not affect the filings so we have no indication of its presence. Wherever there are air spaces, however, the iron-filings arrange themselves to map out the flux paths. This figure clearly shows the general distribution of the magnetic flux about a dynamo due to the field magnets alone, no current being sent through the armature coils. The field between the pole-pieces is everywhere uniform. The leakage, or flux not passing through the armature, is also shown and by comparing the map of this field with the

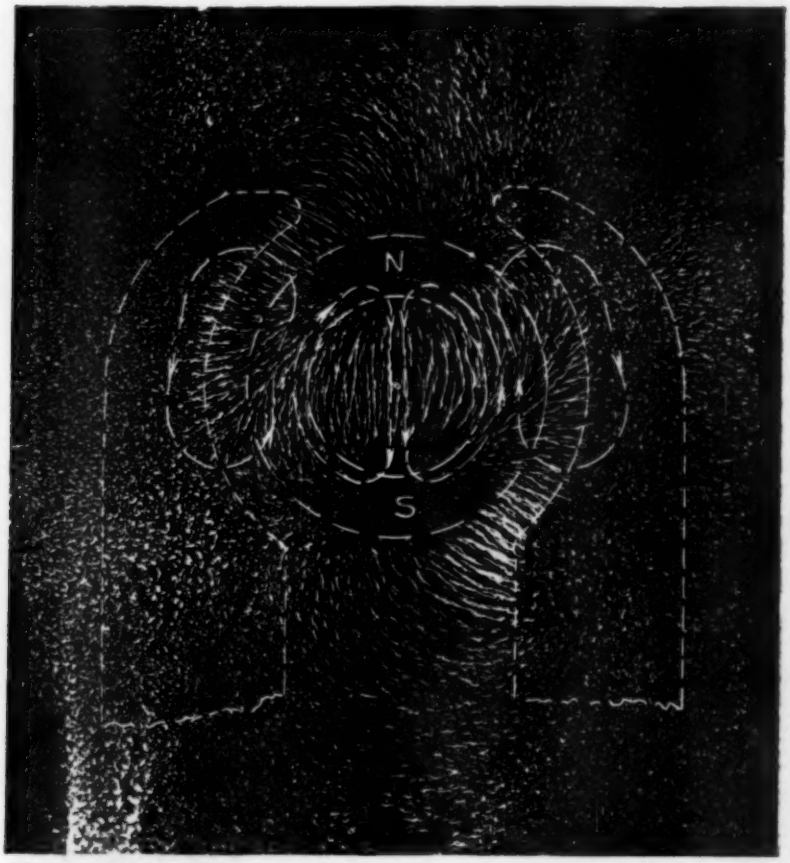

FIG. VI.

map of the field obtained with no armature ring in the magnetic circuit we see that the leakage is very appreciably decreased by the introduction of the armature.

Since iron-filings show flux over air spaces only, the air-gaps were made unduly large for the sake of clearness. While they are relatively much larger than for commercial machines, leakage in an actual machine would have the same general arrangement although it would be proportionally much less in amount. This can be shown by replacing the ring with an armature of a size corresponding to commercial clearance.

Another point of interest is that the iron-filings within the center of the ring are but very slightly affected by the flux showing that the greater amount of the flux takes the path of

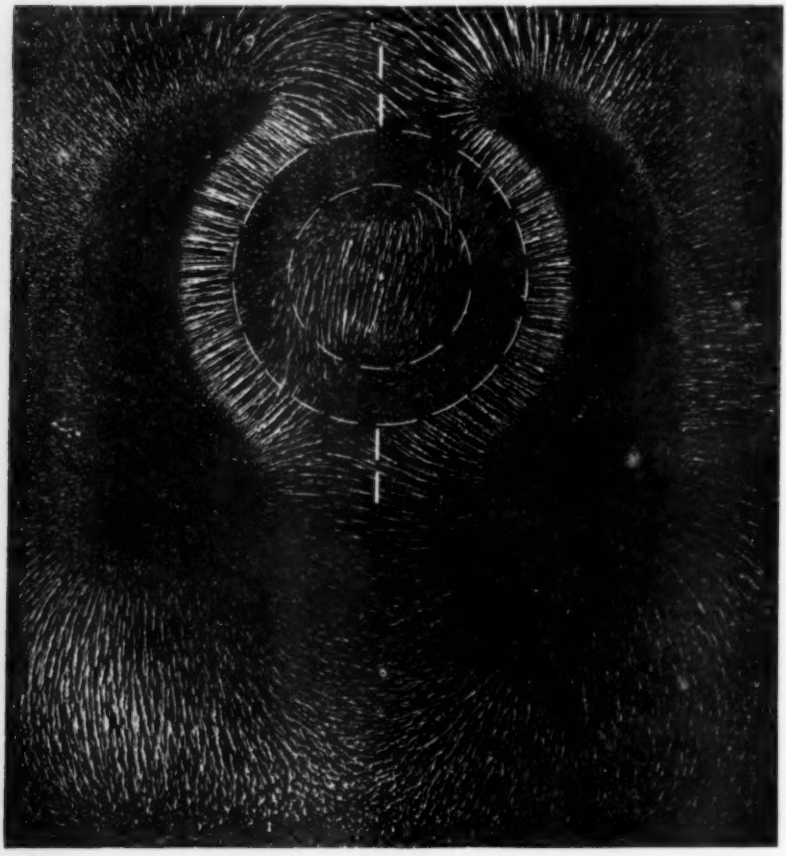

FIG. VII.

greater permeability. This very clearly shows the magnetic effect that is applied in the iron magnetic watch protectors, in the iron casings of electrical instruments and elsewhere to protect against stray magnetic fields.

In order to show the magnetic field that would be set up by the armature alone the field coils in figure V were disconnected and current sent through the armature only. Current entering at E, figure III, divides, half of it passing around one side, G, of the ring and half around the other side, H, tending to produce double poles in the ring at E and F. A portion of the flux completes its path through the pole pieces as shown by the dotted lines, while the tendency to cross magnetize is shown by the strong flux sent across the ring at right angles to the direction

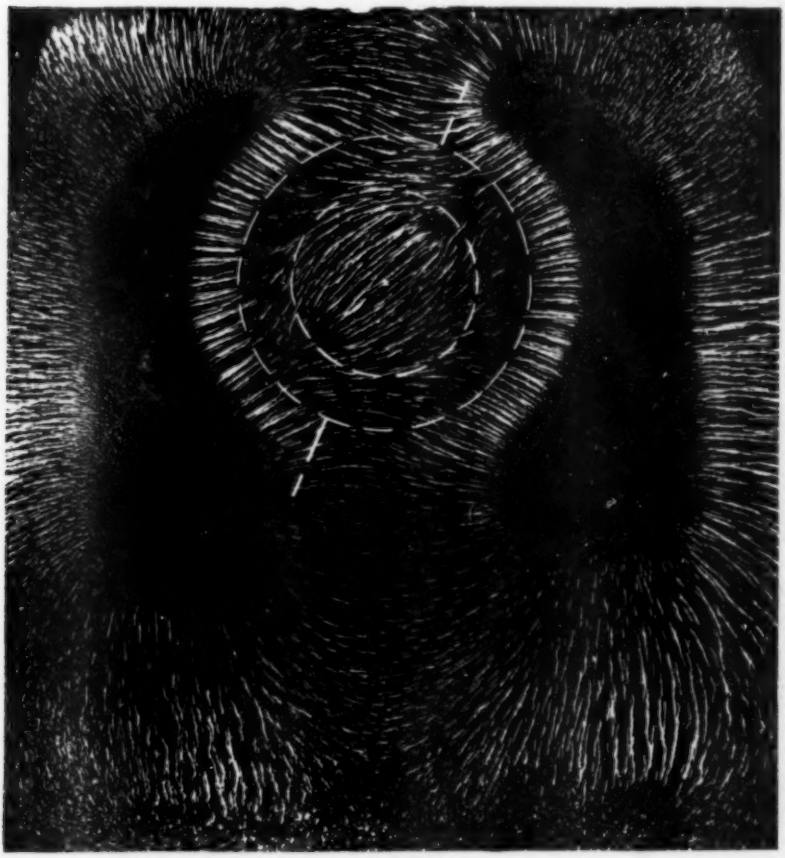

FIG. VIII.

of the flux that would be produced by the field magnets alone as shown in figure IV.

In actual dynamo operation both the exciting coils and the armature coils are working, tending to set up fields as shown in figures V and VI. The superposition of the two gives rise to the resultant field shown in figure VII, which may be taken as typical of the real field of a working dynamo. The cross magnetizing tendency of the armature is shown in the flux path, outlined, across the ring. This now passes obliquely across, the poles of the armature ring being in effect shifted in the direction of rotation. The field between the pole-pieces is weakened on one side of the leading in and out brushes and concentrated on the opposite side so that the armature if rotating would not be moving through a uniform field.

Further we can show that reversing either the armature or field current causes the distortion to be reversed but that reversing of both causes no change in the distortion.

Points E and F on the armature correspond to the points at which brushes would be making contact in an actual dynamo and by turning the armature ring in the direction of rotation we are able to show the effect of shifting the brushes. Comparing figures VII and VIII we at once notice that the flux lines have been less distorted and that there is less weakening and concentrating of flux at the pole tips. Shifting the brushes against rotation (turning the armature ring the opposite direction) shows the opposite effect.

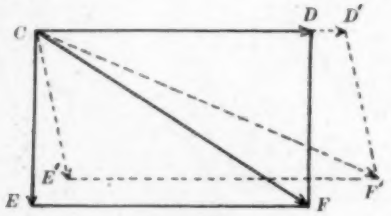

FIG. IX.

These effects can be made clearer by applying the parallelogram law to the magnetic forces. If in figure IX we let CD represent the field flux and CE the armature flux and complete the parallelogram we obtain the direction of the resultant field. Changing the value of either CD or CE (by changing the current value in the field or the armature) or the direction of CE (by shifting the position of the brushes by rotating the armature ring)

the reason for the change of direction of the resultant field is evidenced by the direction of the diagonal of the parallelogram CD′ CE′.

This simple apparatus might be used to demonstrate still more of the magnetic relations of generators and motors but a study of both the two- and the four-pole models as suggested here is all that most secondary schools will be able to consider because of a lack of time.

For quick reference to any other field produced by other conditions it is found convenient to make blue-print mappings of the fields. This is easily accomplished by placing a sheet of blue-print paper over the sheet of cardboard or glass in a semi-dark room and lightly sprinkling iron-filings over the paper and gently tapping the cardboard. When the field is satisfactorily outlined raise the shade and allow to print and finish as usual for blue-prints.

NOTE.—For detailed drawings of these model fields apply to the Chairman of the Joint Committee on Physics, Pratt Institute, Brooklyn, N. Y.

ANIMALS AS CONVERTERS OF PLANT NOURISHMENT INTO HUMAN FOOD.

The cost of production of our nourishment is one that is growing in importance and seriousness from decade to decade. In the extensive use of animal foods, so common in most civilized nations today, it is rarely borne in mind that the production of this type of food involves a conversion of plant food into animal food—a transformation necessitating a sacrifice of considerable energy. The animal which devours the plant products requires no small proportion of the stored energy for its normal life processes. What is left available for the production of meat and fat or the secretion of milk, which may become available to man as food, must represent a small portion of the actual nutrients originally stored in the plant. To what extent is it possible for mankind to attempt to avoid this waste of energy by making direct use of the plant products which are ordinarily converted to our advantage by the herbivorous animal. In attempting to answer this question we must bear in mind the diverse character of some of the plant products which are ordinarily consumed by man and the plant-eating animals, respectively. The latter utilize such natural products as straw, grass, leaves, etc., which ordinarily form no part of the human dietary. These products are relatively rich in cellulose and related substances, which are not of use to the human individual.

The value of animal production lies in the fact that it transforms into more readily utilizable food products nutrient materials for which the human body is not well adapted. In order to furnish nutriment to the maximum population from the natural resources of the land, the more digestible vegetable products should be applied directly for the nutrition of man, whereas the more resistant ones should be converted to his use by feeding them to animals. The respective rôle of the two types of organisms ought to be borne in mind, says *The Journal of the American Medical Association*, whenever conditions arise which call for a maximum utilization of the products of the soil for the maintenance of a large population.

SOME ROCK ANALYSES.

By Nicholas Knight,
Cornell College.

1. The Red Sandstone of Heidelberg.

Many of the buildings of the University of Heidelberg, as well as other public and private buildings of the city, are composed of a hard, compact, fine-grained and durable variety of red sandstone. It makes a handsome building material, as well as durable, as illustrated by the beautiful new University library, one of the finest structures in Southern Germany. The rock exists in great quantity in the hills about the city, and is easily accessible, so it seems to be the chief building material of the region. A specimen of the rock was recently analyzed by Harold A. Knight, the results of which are as follows:

SiO_2	81.36 per cent
CaO	1.82 per cent
MgO	1.57 per cent
Fe_2O_3	1.82 per cent
Al_2O_3	12.17 per cent
H_2O	0.99 per cent
CO_2	0.00 per cent
	99.73 per cent

The rock is a sandstone, as its appearance indicates, with admixtures of calcium, magnesium, iron and aluminum silicates. Doubtless these silicates are the portion that cement the particles of sand together.

2. The Rock from Melrose Abbey.

Melrose Abbey, one of the places immortalized by Sir Walter Scott, and the most beautiful and imposing ruins in Scotland, is composed of the old Red Sandstone. The Abbey is now owned by Lord Buccleugh, and is annually visited by thousands. The rock is a hard and durable sandstone, or it could not have withstood the rigors of the Scottish climate for so many centuries. The analysis was made by Paul Busenbark:

SiO_2	71.79 per cent
Fe_2O_3	17.60 per cent
Al_2O_3	7.40 per cent

CaO	1.20 per cent
MgO	.90 per cent
H_2O	0.62 per cent
CO_2	0.00 per cent
	99.51 per cent

The rock is a sandstone, composed of the same mineral constitutents as the Heidelberg formation, with a much larger percentage of iron.

3. A Specimen from the Lauterbrunnen Valley.

This valley is not far distant from Interlaken, in the midst of the lofty peaks of the Alps. It is about a half mile wide and traversed by a small, limpid, swiftly moving stream. The specimen of rock was picked up near the Staubbach (dust brook) waterfall, which plunges nine hundred and eighty feet at a single fall. Lord Byron compared the fall to the tail of a white horse streaming in the wind. The rock is hard and durable, used as a road material and for buildings. The analysis was made by Harold A. Knight:

$CaCO_3$	87.52 per cent
$MgCO_3$	5.81 per cent
SiO_2	4.61 per cent
Fe_2O_3	0.16 per cent
Al_2O_3	1.95 per cent
	100.05 per cent

The rock is quite a pure limestone.

4. A Specimen from the Dolomites.

One of the most picturesque routes in Europe is the one through the Austrian Tyrol from Venice, the quaint mistress of the Adriatic, to Innsbruck, the quaint and interesting city of Austria. In this region is included Pieve of Cadore, immortalized as the birthplace of the greatest Italian painter, Titian. Dolomiea, the French scientist, was the first to call attention to this curious rock formation in the Austrian Tyrol, which proved to be magnesian limestone, and so the term *dolomite* originated. The mountains attain an elevation of ten thousand to eleven thousand feet, but not all the rock is dolomitic. The specimen analyzed was obtained at Brenner, the summit of the pass, 4,495

feet above the level of the sea, and forming the watershed between the Adriatic and Black Seas. The specimen is not dolomite, but quite a pure variety of limestone. The analysis was made by Paul Busenbark:

$CaCO_3$	96.25 per cent
$MgCO_3$	2.98 per cent
SiO_2	0.35 per cent
	99.58 per cent

It is such pure limestone that it would meet the requirements for calcium carbide and for Portland cement.

5. Rock from the Roman Catacombs.

The Catacombs have appealed strongly to the imagination of the Christian world down through the centuries. They comprise 615 acres, nearly a square mile, far below the Eternal City, and some authorities estimate that they were the burial place of two millions of the early Christians. The Catacombs are constructed in the granular tufa (tufa granulare). Its firmness was an advantage for the vertical walls of the galleries, and it was also safe from cave-ins. It is of a reddish-brown color and of medium hardness. It is of volcanic origin, like the seven hills of Rome, and much of the outlying country, known as the Campagna. The specimen was obtained in the summer of 1912 from St. Sebastian's Catacomb. It was analyzed by Glenn H. Miller, as follows:

SiO_2	47.68 per cent
Al_2O_3	31.64 per cent
Fe_2O_3	11.48 per cent
CaO	3.87 per cent
MgO	3.27 per cent
K_2O	0.21 per cent
Na_2O	1.72 per cent
TiO_2	0.63 per cent
P_2O_5	0.35 per cent
	100.85 per cent

All the iron was determined as Fe_2O_3, whereas a portion may be FeO. This may account for the excess in the result.

This may be compared to a specimen of Tufa from Hawaii, the analysis of which is reported by Dr. H. S. Washington:

SiO_2	47.44 per cent
Al_2O_3	16.51 per cent
Fe_2O_3	15.33 per cent
FeO	3.19 per cent
MgO	8.80 per cent
CaO	6.02 per cent
Na_2O	1.60 per cent
K_2O	0.30 per cent
P_2O_5	0.61 per cent
MnO	0.37 per cent
	100.17 per cent

CHEMISTRY IN GERMAN.

By Jessie Coplin,
Minneapolis, Minn.

No, not chemistry in Germany; but a class in one of our High Schools which uses a German chemistry as a text and recites in the German language.

I have always been enthusiastic about Ostwald's "Schule der Chemie." I think the vocabulary is simple, the sentences comparatively short, and the conversational style is charming. And of course the subject-matter is authoritative.

I had gotten many ideas from the book and when finally the one volume edition came out, I began to think of a class which would use the book. Through the school board we now own seven copies of "Die Schule der Chemie." They arrived about seven weeks before the close of school and I soon had four satisfactory volunteers from my second term classes, each with three years of preparation in German. Each one kept up with the regular recitations also.

The class developed into one for sight reading with questions and discussions, in German, as required, and with experiments as described in the text. There was also at the beginning of each period a review of new and important words, and also of the preceding day's lesson. There was very little translation. We averaged three pages a day after the first week. We began with the chapter on sodium as they had already studied that subject, then came copper, silver, photography, iron.

The four young people were very enthusiastic over the book itself and their increased vocabulary. The German teachers were glad to have their work correlated. They were glad to have the sight reading method.

Another year, I want to try again. I do not think that I want to start until the class has finished one term of work (we have mid-year classes, also). I would begin with sight reading, let each one make a dictionary out of cards, and later, perhaps, shift to a prepared lesson.

"PLANETARY" WINDS AND DISTRIBUTION OF RAINFALL; A DEDUCTIVE STUDY.

By R. R. Turner,
University of Illinois.

1. Assuming gravitational flow under differences in pressure, and rotational deflection, predict the planetary winds from a generalized isobaric chart of the world for the year. It is best first to consider the southern hemisphere as the simpler. Call attention to distortion of polar regions by Mercator's projection; the southern "Low" is marked by a series of *concentric* isobars, and the prevailing westerly winds of high latitudes form a "circumpolar whirl."

Use isobaric and wind charts of the polar regions on a polar projection (July for southern hemisphere, January for nothern).

2. Study the actual "planetary winds," comparing with the theoretical ones.

3. Causes of the planetary distribution of pressure:

(a) The equatorial "Low" caused by heating.

(b) The polar "Lows" caused by the centrifugal tendency of the whirl which must result from a meeting of winds directed toward the pole and deflected by rotation.

4. Seasonal and other variations in pressure distribution, using isobaric charts of the world for January and July. Note that "Lows" are usually on land in summer, on ocean in winter. Why? Monsoons, which are merely local exaggerations of this effect. Note more pronounced pressure gradients in winter, causing planetary winds to be more regular then.

5. Surface ocean currents as results of planetary winds.

6. A more detailed study of winds and especially of rainfall distribution; such as outlined in Davis' "Practical Exercises in Physical Geography," using world charts of prevailing winds. This study may well be subdivided as follows:

1. Wind belts; location and characteristics.
2. Migration of wind belts; causes and effects.
3. Periodic winds; monsoons, etc.
4. General distribution of rainfall; dependence upon winds, location of oceans, mountains, etc.
5. Seasonal changes in rainfall; correlate with either: (a) migration of wind belts, or (b) monsoons.

THE HEAT OF FUSION OF TIN.

By C. W. Waggoner,
West Virginia University.

After observing the results of examinations in heat for a number of years the writer has found that, despite every effort otherwise, students get an idea that water, or ice, is the only substance that possesses a heat of fusion; and the common answer to the question, "What is a heat of fusion," is, "The amount of heat required to melt a gram of ice." It seemed desirable then, to find an experiment which would make clear the fact that every pure, crystalline substance has a heat of fusion. The writer claims no particular originality in the method for the determination of the heat of fusion of tin described below, for it will be found, in various forms, in some of the standard laboratory manuals in physics, but the apparatus is so simple and the results are so gratifying that he feels justified in calling it to the attention of physics teachers at this time.

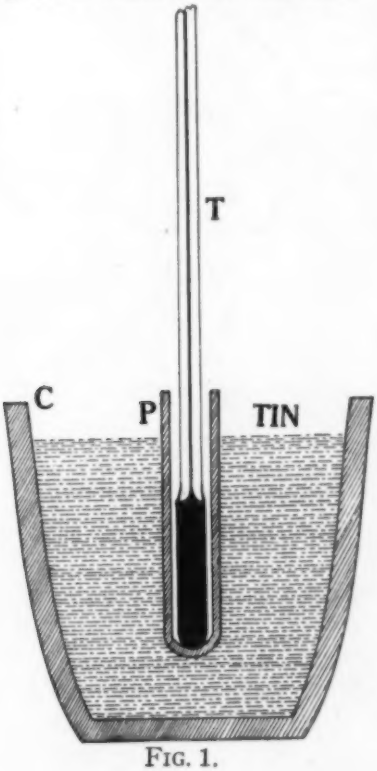

Fig. 1.

The method is essentially a cooling-curve method and consists in heating a quantity of tin to a temperature somewhat above the melting point and then making a time-temperature cooling curve, making readings of the temperature for some little time after the molten tin has solidified.

The necessary apparatus is shown in figure 1, which consists of a No. 000, Dixon Graphite Crucible, C; a 360° C. thermometer, T, which may be purchased from the supply houses for $0.55 each, and these are sufficiently accurate for student work; an iron shield, P, to protect the thermometer when the tin solidifies. This last may be made by boring out the center of a soft iron rod so as to make a thin iron shell closed at one end. The writer's students use a Mèeker Gas burner for melting the tin because this burner gives a very high temperature, but a good Bunsen burner should serve equally well for the melting temperature of tin is only 232° C.

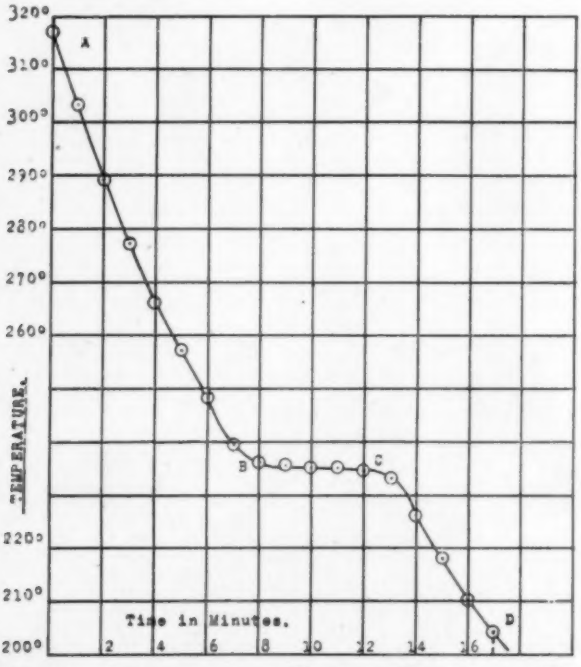

FIG. 2. SHOWING THE COOLING-CURVE FOR TIN.

Figure 2 shows a time-temperature curve taken at random from a student's laboratory report. The method of computing the heat of fusion consists of finding the average rate at which

the crucible and its contents lose heat, both before and after solidification; then the assumption is made that during the time of solidification, or B C, in Figure 2, the process of solidification produces sufficient heat to prevent the lowering of the temperature by radiation, conduction and convection. Knowing the time of solidification, the average heat loss per minute before and after solidification, and the mass of the tin, the heat of fusion may be calculated.

The following data was taken from a student's report.

Wt. of Tin=94 g.	Sp. Ht. of Molten Tin=0.064.
	Sp. Ht. of Solid Tin=0.060.
Wt. of Crucible=115 g.	Sp. Ht. of Crucible=0.200.
Wt. of Iron Shield=16.5 g.	Sp. Ht. of Iron=0.116.

Water Equivalent of the Crucible and Shield=24.91.

Average loss of heat before and after solidification=269.44 Calories per minute.

Time of solidification (from curve)=4.5 minutes.

Heat of Fusion of Tin=12.9 calories.

The presence of the iron protecting shield causes some temperature lag as shown by the rounded corners at the solidification temperature, but this may be prevented to a certain degree by introducing some mercury in the thermometer shield thereby insuring a little higher rate of heat flow to the thermometer.

The most obvious points of interest to the student are:

1. The measurement of temperatures above the boiling point of water.
2. The sharp, definite melting point of a pure, crystalline substance.
3. The heat of fusion of a metal.
4. The calculation of the heat lost as a body cools freely in the air.
5. The determination of a "heat quantity" without resorting to the "time-honored" method of mixtures.

The writer is well aware of the fact that the method described has errors which would prohibit its adoption in careful research work, yet it has proved to be an experiment of considerable interest and profit to his students—which is alone the justification for this discription.

COLLOIDS.[1]

By Harry N. Holmes, Ph. D.,
Earlham College, Richmond, Ind.

Colloidal chemistry is just half a century old and the great mass of knowledge in this field has been gained in the last decade. The world is only beginning to realize the enormous importance of colloids to chemistry, physics, biology, mineralogy, medicine, agriculture and chemical industries.

In 1862 Graham observed that many substances in aqueous solution diffused very slowly, if at all, through parchment paper or animal membranes such as bladder and these he named "colloids." The term "crystalloids" was given to substances which diffused readily through parchment paper because they could generally be obtained in crystalline form. Graham's list of colloids included glue, gelatin, albumen and dextrin, all of them amorphous bodies. Faraday and others had prepared such solutions at an earlier date but they had given the subject little systematic study. Graham developed methods for obtaining supposedly insoluable substances like ferric hydroxide and silicic acid in what appeared to be real solutions. To the naked eye they seemed clear and homogenous yet they would not diffuse through parchment so he classed them as colloids rather than true solutions. He found that these "sols," as he finally termed them, differed from salt solutions in that they were easily precipitated by small quantities of electrolytes. The modern view is that the colloidal condition is a state of matter and that all substances, even crystalloids, can be converted into colloids.

General Methods.

Several methods for obtaining this condition are now known and some knowledge of them is essential to a conception of colloids.

Merely dissolving certain substances in water is probably the simplest method. Gum arabic and glue come under this head. There is no sudden change in their solutions with change of temperature. Gelatin dissolves in hot water but sets to a jelly on cooling, the exact point depending on the concentration. On reheating this jelly again becomes fluid. Egg albumen is soluble at ordinary temperatures but coagulates on boiling. Agar-agar

[1]Address delivered before the Indiana Science Teachers' Association.

and starch are also converted into very fluid "sols" on heating with water and gelatinize into "gels" on cooling.

By Bredig's method metallic colloids may be prepared. Two gold wires, for example, are made the terminals of a 110-volt circuit carrying from five to ten amperes. These wires are brought together and separated many times under pure water forming small electric arcs. Clouds of fine metallic particles are thrown into the water from the cathode. The larger particles are removed by filtration but the filtrate is a clear red or blue and can be shown to contain metallic gold. The addition of a trace of caustic soda facilitates the pulverization. Colloidal platinum is prepared in similar manner but does not need the alkali. The most concentrated colloidal platinum solutions contain about one-tenth of a gram to the liter. Several metals may be treated in this way but some are colorless and none as beautiful as the gold solutions. With certain precautions colloidal sodium was obtained recently using cold ether instead of water. Svedberg's improvement on this method is worth study.

Compounds ordinarily considered insoluble may be obtained in colloidal form by reactions yielding no ions as a by-product. As_2S_3 is insoluble yet it is not precipitated when hydrogen sulphide is passed into a solution of As_2O_3.

$$As_2O_3 + 3H_2S = As_2S_3 + 3H_2O$$

If to this yellow solution a few drops of any acid or salt solution be added the As_2S_3 soon settles to the bottom of the tube. The common feature of acids and salts is that they all yield ions in aqueous solution so the coagulating effect must be due to the electric charges on these ions. Had the hydrogen sulphide been passed into a solution of $AsCl_3$ an immediate precipitate would have been obtained.

$$2AsCl_3 + 3H_2S = As_2S_3 + 3HCl$$

The HCl formed in the above equation ionizes and coagulates the As_2S_3. This method is not general but it has several applications.

A modification of the above method is possible with such insoluble compounds as are coagulated rather slowly by ions. $Fe(OH)_3$, for example, is not so sensitive to electrolytes as is As_2S_3. At high dilutions it may be secured in colloidal condition using reactions that yield ionizable compounds—if the ions

are rapidly removed by dialysis. A dialyzer is conveniently made by cutting the bottom out of a bottle, tying parchment paper or goldbeater's skin over the mouth and suspending the bottle, inverted, in a jar of pure water. If the bottle is filled with a solution containing both colloids and crystalloids the latter will diffuse through the membrane into the pure water of the outer jar finally leaving a pure and fairly stable colloid in the bottle. The water in the outer jar must be changed frequently. There are several ways to make colloidal $Fe(OH)_3$ but one will serve for illustration. To a very dilute solution of $FeCl_3$ add less NH_4OH than the amount required to form a precipitate.

$$FeCl_3 + 3NH_4OH = Fe(OH)_3 + 3NH_4Cl$$

By dialyzing this red-brown solution the crystalloid NH_4Cl is removed before it has time to coagulate the colloidal $Fe(OH)_3$.

Reduction methods are used in preparing hydrosols of some of the noble metals, notably gold. Four cubic centimeters of a one per cent solution of gold chloride are diluted with 100 cc. of water and a solution of two grams of tannic acid in 100 cc. of water prepared. On mixing equal parts of the two solutions a ruby red sol of gold results but if one part gold solution is added to three parts tannin a blue gold sol is obtained. The reduction takes place in one minute. A large number of reducing agents have been used in making colloidal gold from the chloride. Ferrous sulphate, oxalic acid, photographic developers such as hydroquinone, carbon monoxide, formaldehyde, hydrazine hydrate, hydroxylamine hydrochloride, dilute hypophosphorous acid, phenylhydrazine hydrochloride and many other reducing agents are effective, some of them more so in the presence of a trace of dilute alkali.

One of the most interesting and important methods of preparing colloids is the use of protective colloids to prevent the coagulation of the colloid desired. An illustration will serve to make this clear. Solutions of tenth normal silver nitrate and potassium bromide containing about one per cent of gelatin do not yield a precipitate of silver bromide when mixed yet in the absence of the protective effect of the gelatin a curdy precipitate quickly settles. It is probable that the minute particles of silver bromide first formed are at once covered with a film of the gelatin which prevents the union of such small particles into aggregates large enough to settle.

The Nature of Colloids.

Graham thought there was a sharp distinction between colloids and crystalloids but it is now known that the two extreme conditions gradually merge into each other. Colloids are merely aggregates of molecules, in some cases of thousands of molecules, distributed through a liquid with apparent uniformity. The very small osmotic pressure of colloids is in accord with the comparatively small number of separate particles. In a true solution containing the same number of solute molecules the number of separate particles dissolved is infinitely greater with correspondingly large osmotic pressure. Since depression of the freezing point and rise of boiling point of a solvent are functions of number of dissolved particles colloids must have little effect on these phenomena.

Dialysis is easily understood by the conception that the minute pores or capillaries in the membrane are large enough to permit the free passage of single molecules in solution but too small to allow the large molecular aggregates known as colloids to get through. The same conception explains why a gel allows crystalloids to diffuse freely but permits little diffusion of other colloids. In fact, dialyzing membranes are themselves colloidal gels.

A colloidal solution is now conceded to be a heterogenous mixture of two physico-chemical phases. The great mass of one phase is practically continuous and this is the solvent, generally water. It is called the "continuous phase" or "dispersion medium." The second phase is in a state of very fine distribution exposing an enormous surface to the other. It is termed the "disperse phase."

Much of the evidence in favor of the heterogenous theory is due to the ultramicroscope invented by Zsigmondy in 1905. This ingenous instrument utilizes the Tyndall effect of light in a remarkable manner. It is well known that a beam of light passing through dust-free air is invisible when examined transversely but the presence of floating dust particles gives the beam of light sharply defined boundaries. Of course this is a mere matter of reflection of light from the dust motes. In similar manner a beam of light may be passed through certain liquids or solutions without detection when examined transversely but if colloids are introduced the path of light is at once made visible. Obviously

the hydrosol must contain floating particles of sufficient size to reflect rays of light.

In the ultramicroscope the colloidal solution is illumined transversely by a narrow but powerful beam of light and the reflected or refracted rays pass at right angles through a powerful microscope to the eye of the observer. The eye is not blinded by the original beam of light but receives only a minute fraction. Each particle is seen as a source of light like the fixed stars and it is estimated that the smallest gold particles visible by this device are 5 $\mu\mu$, or millimicrons, in diameter. A micron is .001 millimeters and hence a millimicron is one millionth of a millimeter. Such a particle of gold probably contains at least a thousand molecules. The microscope proper cannot show separate particles of a smaller diameter than 250 $\mu\mu$ or millimicrons. This is the shortest wave length of visible light.

The method of calculation of the size of colloidal particles is interesting. The volume of the illuminated liquid is determined by an eye piece micrometer and the number of particles in this volume counted. If the concentration of gold, for example, in the sol is known the weight of gold in the illuminated volume is also known and from this and the number of particles the weight of each particle may be determined. Assuming the particles to be spherical or cubical with the same density as solid gold the diameter can easily be calculated.

In many organic sols only a diffused light can be seen, no stars, and this may be due to extreme smallness of particles or to their having a refractive index near that of the liquid.

It must be borne in mind that there is a wide range in size of colloidal particles from aggregates of a few molecules too small to be visible even with the ultramicroscope to those just visible with the naked eye, in fact, to any slow settling suspension. If a mixture of clay, sand and pebbles be shaken with water and allowed to stand the pebbles settle at once, the coarse sand very soon, the fine sand in a few minutes but some of the clay may take days to settle. The clay suspension is colloidal.

The Brownian movement is one of the most remarkable phenomena observed with the ultramicroscope. The particles of the disperse phase are possessed of a vibratory movement, hopping and dancing about. They move around a central position with some translatory movement in addition. Particles more than 3 μ or 5 μ in diameter do not show this motion and it becomes

more rapid with decreasing size. A suspension of gamboge shows the phenomenon under a magnification of only 500 diameters and a simple dark ground illumination with a central stop in the ordinary condenser. Einstein and others insist the Brownian movement is due to the impact of molecules of the liquid on the disperse particles and is influenced by temperature, viscosity, diameter of the particles but not by the mass of the particles. Perrin showed that particles in Brownian movement tend to fill the space in which they are contained just as do molecules of a gas or dissolved substance. They obey the gas laws.

The close relation of colloids to true solutions is shown by Lobry de Bruyn's experiment in centrifuging a saturated solution of Glauber's salt. Three-eighths of the salt crystallized out.

The electric charge carried by a large number of colloids gives them rather interesting properties. There is a potential difference between the liquid and the suspended particle and when the terminals of a 110-volt circuit are placed in the suspension the particles migrate to one pole or another depending on the nature of the charge carried. Most charged colloids are negative like the sulphides, metals, acids and clay. The metallic hydroxides are positive and basic substances in general carry positive charges. Yet such important colloids as glue, gelatine, agar-agar, starch and albumen carry very little or no charge. Naturally they do not migrate in an electrolytic cell. This statement, however, must be modified for amphoteric colloids like albumen are negative in alkaline liquids and positive in acid. In a number of cases it is true that the charge on a suspended particle is variable in acid, basic and neutral solutions. The charge on the disperse phase may be different in different continuous phases. Colloidal platinum, for instance, is negative in water but in a mixture of water and alcohol is positive. Many theories are advanced to explain the source of these colloidal charges. It is known that there is always a difference of potential at the surface of contact of two unlike substances and of course the contact surfaces between a disperse phase and the continuous phase are enormous so the contact electricity is considerable. Another conception is that some colloids throw off ions leaving the molecular aggregate with a charge. It is also suggested that the hydrogen ions of water are adsorbed by some colloids with retention of the positive charge while others retain the hydroxyl ions of water and a negative charge.

Coagulation.

Colloids carrying electric charges are easily precipitated by the addition of relatively small quantities of electrolytes. In the case of negative colloids like arsenic sulphide the precipitating power of the electrolyte increases wonderfully with the charge on the cation and is independent of the nature of the anion. With positive colloids such as ferric hydroxide the opposite is true. The precipitate always carries down some of the precipitating ions hence the coagulation must be due to neutralization of the colloidal charges. It is no surprise now to learn that oppositely charged colloids may precipitate each other. Suspensions of arsenic sulphide and ferric hydroxide mixed in the right proportions form a precipitate.

There is, of course, a minimum concentration below which an electrolyte will not produce coagulation of a certain colloid and it is interesting to note the values found by Freundlich in the case of colloidal arsenic trisulphide. Its concentration was 1.854 grams or 7.539 millimoles per liter (a millimole being one-thousandth of a gram molecular weight). The concentrations of various electrolytes required to coagulate the arsenic trisulphide are given in millimoles per liter:

KCl 49.5	$MgCl_2$ 0.717	$AlCl_3$ 0.093
KNO_3 .....50.0	$CaCl_2$ 0.649	$Al(NO_3)_3$ ...0.095
NaCl 51.0	$BaCl_2$ 0.691	
LiCl 58.4	$Ba(NO_3)_2$ ...0.687	
HCl 30.8		

It will be noted that in the first column with univalent cations there is little variation in coagulating power. In the second column with bivalent cations the values are in close accord. It is a striking fact that the concentration of univalent cations required to produce coagulation of the colloid used was 80 times greater than the concentration of the bivalent cations and 600 times greater than that of the trivalent cations.

The precipitation of colloids by ions is a natural result of the neutralization of the colloid charges. Once free from the similar charges which caused them to repel each other these minute particles can unite to form aggregates sufficiently large to settle.

Colloids insensitive to electrolytes are generally organic compounds and are coagulated by heat or the addition of a great excess of concentrated salt solutions (the so-called "salting out"

process) or the addition of other solvents such as alcohol. Such colloids are reversible.

Reversible colloids such as gelatine, agar-agar, starch, glue and many other organic compounds possess the property of swelling up with water and forming a solution on warming. On cooling they gelatinize to a soft, viscous mass which retains all the solvent water. The solution is termed the hydrosol and the gelatinized mass the hydogel. If alcohol is used instead of water the terms are alcosol and alcogel. On evaporating the water at low temperatures from a hydrosol a hydrogel is formed and if the process is not carried too far this may be redissolved by the addition of water.

The irreversible colloids when coagulated cannot again be redissolved except by special methods. This class is very sensitive to electrolytes and includes the colloidal metals, sulphides, hydroxides, etc. They are generally much less viscous than the reversible class.

Protective colloids belong to the reversible type which we later shall refer to as emulsoids and in relatively small quantities are able to increase the stability of many sols or, in other words, prevent coagulation. Barium chromate when formed in pure water solutions never leaves a colloidal suspension yet the addition of very little casein to a barium salt solution readily yields colloidal barium chromate when mixed with some soluble chromate. Colloidal gold, for instance, resists coagulating agents much better when one per cent of gelatin is present. In fact the relative effects of different emulsoids has been studied by Zsigmondy who determined the quantity of colloid just necessary to protect a definite volume of a standard gold sol from coagulation by a given quantity of sodium chloride. The relative figures vary from 0.005 for gelatine, 0.02 for isinglass and 0.2 for egg albumen, to 12 for dextrine and 25 for potato starch. These are called the gold values of the protective colloids and show that gelatine is the most effective of them all. The fact that it is a palatable food is of great value in medicine for its protective effect is frequently an important aid to digestion.

In recent years Paal has patented a process of making very stable metal sols some of which, copper and mercury, for example, have become important commercially. By the action of alkalies on albumen salts of protalbinic and lysalbinic acids are obtained and these are used to protect metal sols.

Emulsoids.

So far we have laid stress upon suspensoids, that is, colloidal solutions having a solid disperse phase with the metal sols, sulphides, hydroxides as types. Specific properties of the suspensoids are easy precipitation by electrolytes, a viscosity nearly the same as that of the continuous phase, turbidity or opalescence visible to the naked eye and separate particles under the ultramicroscope, Brownian movement and the carrying of distinct electric charges.

The emulsoids, however, consist of two liquid phases, drops or globules of a more concentrated solution distributed throughout a more dilute solution. This is an important class including rubber latex, starch, gelatine, casein, albumen, agar-agar, the gums, nitrocellulose, soaps and many others. These carry little or no charge unless hydrogen or hydroxyl ions are adsorbed from acid or basic solutions. Under the ultramicroscope most of them do not show separate particles but merely a diffused light cone. They froth or foam easily, gelatinize or swell, require large concentrations of salts for coagulation and possess high viscosity. With increase in concentration the rise in viscosity is enormous and with increase in temperature the decrease in internal friction is great.

These emulsoids seem to have a fibrous structure of the more concentrated solution enmeshing the more dilute phase. The gel resulting when gelatine sol is cooled retains all the water of the sol—a marked difference from gel formation in the suspensoid class. The coagulation is probably a transfer of water from one phase to another.

Closely related to this class are the emulsins best illustrated by an intimate mixture of a little oil and a great deal of water. Here the two phases are liquid but they are insoluble in each other. Rubber latex is another emulsin containing globules of rubber and resins suspended in a continuous phase of a solution of proteids. Emulsins are easily made by admitting oils into water or solutions through a fine nozzle or by violent shaking of the mixture. Soap solutions aid in the emulsification of oils because they have very low surface tension thus permitting the formation of extremely small globules with greater rigidity than larger drops. Pickering made an oil emulsion containing 99% oil which was so rigid it could be cut into cubes. Milk is an emulsin of butter fat in a solution of caseinogen, lactose, salts and albumen.

(Concluded in December Number.)

EXPERIMENTAL STUDY OF THE CHEMICAL ACTIVITIES OF LEAVES.

(Working Directions as Given to the Class.)

By R. R. Turner,
University of Illinois.

1. The Effect of Leaf-activity Upon Surrounding Air.

Two bottles of fresh air, containing leafy sprigs, are tightly stoppered. In order to test the effect on "impure" air (containing much carbon dioxide) two bottles are filled with air from the lungs (by filling first with water, then inverting an open dish of water and blowing air through a bent tube into them). Place leafy sprigs in them, and stopper. Two are prepared, in order that the effect of light, if any, may be determined by carrying out the experiment in duplicate in the light and in the dark.

Prepare 4 "control" bottles, just exactly as above, *without the leaves.*

Place one fresh air bottle with leaves, and one impure air bottle with leaves, with the corresponding "controls" in a dark place for twenty-four hours. Place the rest of the bottles in a bright place—sunshine if possible. Test each bottle (a) for carbon dioxide by means of a vial of lime water, (b) for support of combustion.

Tabulate the results of the tests as follows:

		With Leaves		(CONTROL) Without Leaves	
		Oxygen?	Carbon Dioxide?	Oxygen?	Carbon Dioxide?
Dark	Pure Air				
	Impure Air				
Light	Pure Air				
	Impure Air				

By comparing these results obtained with leaves and without leaves, the effect of the leaf-activity may be found in each case. What gas is formed, and what is used? Contrast the effect in the dark with that in the light.

2. Production of Gases by Leaf-activity.

Observe a bit of green aquatic plant (e. g., "fish moss") in a test-tube placed in the sunlight. Note the formation of bubbles.

(a) *What is the gas?* Collect some of the gas by covering

some of the aquatic plant in the water with an inverted funnel. Place an inverted test-tube over the stem of the funnel, to collect the gas by displacement of water. Test with a glowing spark after a considerable amount has been collected.

(b) *What effect does light have, if any?* While this is collecting, find the rate of bubbling in direct sunlight by counting bubbles for two or three minutes, recording average number per minute. Repeat in diffuse sunlight, then in a dark corner of the room.

(c) *Do the gases dissolved in water affect the action?* Test by transferring to water which has been recently boiled. In being heated to boiling, dissolved gases are caused to escape (the bubbles rising before boiling begins, are gases escaping from solution).

(d) Boiling removes *all* gases from the water. What would be the effect of removing only one? What gas has been shown (1) to be used up in leaf-activity? By adding a little limewater to some ordinary (unboiled) water, all the dissolved carbon dioxide may be used up. Test for the bubbling action in this water. Conclusions?

(If you suspect that limewater may injure the plant, replace it in fresh water, and see if action continues.)

(e) What would be the effect of water containing carbon dioxide alone in solution? Test this by using water which has been boiled to expel all dissolved gases, and then saturated with carbon dioxide from a generator.

3. The Production of Starch in the Leaf.

The test for starch in leaves is made by treating the leaves with a solution of iodine, after first placing them for a few seconds in boiling water, then soaking in alcohol until all the green coloring matter ("chlorophyll") is dissolved out. The presence of starch is shown by a blue or black color, which is to be distinguished from the brown stain of the iodine itself.

(a) What effect does light have upon starch-production? Test for starch in two leaves, one of which has been exposed to direct sunlight, the other kept in darkness for twenty-four hours. The effect may also be shown in a single leaf, part of which has been shielded from the light by a covering of tin-foil, or by corks.

(b) What effect does carbon dioxide have upon starch-production? Place a leafy sprig in a stoppered bottle containing some

soda-lime, fitted with an exit tube to which a U-tube containing soda-lime is connected. The soda-lime absorbs carbon dioxide, and thus keeps the air about the leaves free from this constituent. Place a similar sprig in another bottle, but leave it exposed to the air containing carbon dioxide. After both have stood in a sunny place for a day, test a leaf from each for starch.

(c) What is the effect of the green coloring matter in leaves (chlorophyll) upon starch formation? Certain kinds of geraniums, ornamental grasses, etc., have variegated leaves; that is, part green and part colorless. Test some leaves of this sort for starch after exposing to light to obtain an answer to the above question.

4. Effect of Colored Light on Leaf Activities.

Any of the above experiments in which the effect of the light is tested—namely, 1, 2-(b), 3-(a)—may be carried out in colored light (e. g., in large bottles of colored glass). Red and green light, especially, should be tried.

HIGH SCHOOL AND RAILROAD CO-OPERATE.

Boys in the high school at McComb City, Miss., earn from $12 to $18 a month regularly while attending school. A plan of co-operation has been drawn up between the high school and the Illinois Central Railroad, whereby the boys attend school one day and work in the railroad shops the next, according to information received at the United States Bureau of Education. The "student-apprentices," as they are called, are paid for their work in the shops, the minimum wage being 12 cents an hour. After four years of combined high school attendance and shop work the boy is prepared to enter college or draw a man's pay at his trade.

Railroad and school authorities both agree that the plan works well. The railroad official in charge of the boys said: "After actual tests it is shown that the plan of co-operation between the Illinois Central Railroad shops and the McComb City High School is not only feasible but that it is working out in a manner entirely satisfactory. I believe it to be for the best interest of the railroad company to fill all vacancies in the apprenticeship system as far as possible with co-operative apprentices." Superintendent Hughes, of the school system, is equally enthusiastic over results from the school's point of view. He believes the plan offers one solution of the problem of keeping boys in school; that it fosters a boy's spirit of independence and satisfies his commendable ambition to get into the game of life.

The McComb City plan is another indication of the strength of the present movement for systematic vocational education in connection with the public schools. It is noteworthy in that it does not lose sight of the need for continued cultural training for the boy who may want to earn his living in the shops.

A THREAD OF MATHEMATICAL HISTORY, AND SOME LESSONS.[1]

By R. D. Carmichael,
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I.

Scientific work often waits long for its full fruitage. The seed of truth is frequently produced at a time when there is no soil ready to receive it; and consequently it must lie quiescent for an uncertain period until preparation has been made for its sowing. And even after it is put into the soil it may happen that centuries will elapse before it can germinate. But it retains its vitality until millenniums have come and passed. Ultimately it springs into growth, slow at first and more vigorous afterwards. Often it comes unexpectedly to florescence and bursts into magnificent flower. Fruit appears, and men begin with joy to reap the harvest of an ancient sowing. For year upon year and century upon century it not infrequently continues to yield its precious increase, and men rejoice in the ever renewed heritage of a remote past; and what they have received they hand on to the future in full vigor and undiminished usefulness. To have a part in creating a new heritage for those in the centuries to come is the most glorious labor which falls to the lot of man.

But to strive through a long life of severe scientific investigation without seeing the direct fruits of one's toil is difficult for many of us, and we need the encouragement which comes from seeing the magnificent usefulness of past research. Even the enthusiastic worker sometimes has a period of despondency when he can take no pleasure in his labors and when he turns away from them with a feeling of tire and disgust. Of Lagrange and his work on mechanics it is said that "for two years the printed volume of his *Mécanique,* which he had seen only in manuscript, lay unopened beside him."

That the teacher also suffers sometimes from the same spirit of dejection is known to most of us through our own experience.

It is thus clear that both the investigator and the teacher should be provided with all the encouragement which the past history of science affords. Considering what this is it is hard to see how they could ask for more. One purpose of this lecture is to illustrate the nature of this encouragement by means of a typical

[1] An address delivered before the Indiana Association of Science and Mathematics Teachers at Indianapolis, Friday evening, March 7, 1913.

example taken from the history of mathematics and its applications to other sciences. We shall trace a certain thread of mathematical history from its origin in ancient times down to the most recent investigations. You are urged to remember that the example taken is merely one of a large number, any one of which would serve well the same purpose; it is not an isolated case, but one which has many instructive parallels.

But, first of all, before giving this account of certain applications of mathematical speculation, let me (as a mathematician) emphasize the fact that mathematics does not exist merely for these applications. In fact they are incidental to its main purpose. Mathematics exists primarily and essentially for itself. If we should attempt to cultivate it for its applications alone we would soon find our progress impeded by barriers which we could not remove. It must be cultivated for its own sake even though many of its results appear for a time entirely useless. How they often have unexpectedly a great value will be seen from the historical sketch which we are about to give.

Let us go back to ancient Greece where so many threads of history have their origin. Here we shall find the beginning of the theory of Conic Sections. One series of consequences growing out of this it is our purpose to treat.

Suppose that we have a right circular cone and cut its surface by means of a plane. If the plane passes through the vertex of the cone the section figure consists of two straight lines. We shall dismiss this case as trivial. When the cutting plane does not pass through the vertex several possibilities arise. In the first and simplest case the section figure is a circle. All the other cases we may look upon as generalizations of the circle. We have a closed figure, which resembles a circle elongated in one direction. We have next a figure with one branch going off to infinity. Finally we have a figure with two branches going off to infinity. These three "conic sections" are known as the ellipse, the parabola, and the hyperbola, respectively.

To the study of these three plane curves the ancient Greek mathematicians devoted much attention, and a large body of elegant theory was built up and rigorously established. The results had no apparent practical applications, and none were sought for them. They seemed to be remote from all experience —a creation of the mind, standing aloof from all useful service.

But this did not deter the investigators. They studied the

curves simply for the sake of their symmetry and elegance. Their object was the pure delight in the artistic beauty of the theory, made complete by the answer to every question which they were able to ask. Working thus and without knowing what they were really effecting, these Greek mathematicians wrote "the grammar of the language in which, it would be demonstrated in after ages, that the pages of the universe are written."

For many generations this body of Greek speculation was practically unaltered. For awhile it was almost forgotten, but it was preserved in the written records of Greek thought. When the revival of interest in ancient philosophy appeared, men were again delighted with the beauty of the theory of conic sections and it was passed along from teacher to pupil, unaltered for many generations and still without practical use or even the use which comes in application to other scientific theories. The era of scholasticism came and passed away. The spirit of the ages changed, and changed again; and yet this body of Greek thought remained unaltered and without application. It was still cultivated and preserved for its own sake.

Then came the dawn of the modern era, brought in by the writings of Bacon. Men still learned again what the Greeks knew of conic sections. A contemporary of Bacon's was at the same time versed in this ancient theory and interested in the study of astronomy. This man was the illustrious Johann Kepler. He was engaged in trying to determine the nature of the planetary orbits. He tried circles, but they would not fit into his data obtained by observation. He tried combinations of circular arcs, but this was no better. He cast about him for other curves of simple properties which might possibly agree with all observations. It occurred to him to try the ellipse, a curve whose properties were so well known to him through his acquaintance with Greek mathematics. To his delight he found that all his data fit perfectly into the scheme of an elliptic orbit. Nowhere was there greater deviation than might be accounted for by experimental error. His quest ended in success, because thousands of years before his time the Greek mathematicians had been interested in the theory of conic sections for its own sake.

But this was not all. Once the form of the planetary path was known to him, Kepler was able to take up successfully several fundamentally important questions which before had re-

mained inaccessible to treatment—in fact, they had hardly been framed by his predecessors. The same Greek tools which he had already employed again served his purpose; and the outcome of his investigations was the enunciation of those laws of astronomy which have since been associated with his name. Thus the foundation of modern astronomy was laid; and the methods by which it was accomplished depend essentially on the ancient theory of conic sections.

This, I believe, was the first important fruitage of that part of Greek mathematical speculation which we are considering; and, as the first, it is the beginning of a long line of magnificent discoveries which is not yet terminated. Let us follow the thread down to our own time, even though we shall have to watch closely to avoid losing it in the great body of our present day science.

A few years after the death of Bacon and of Kepler the great English physicist Sir Isaac Newton was born (1642). The great advances in astronomy due to the discoveries of Kepler naturally turned men's thought in that direction. In the early years of his life Newton meditated upon the elegant laws of Kepler. The question uppermost in his mind was this: What is the ultimate law of nature upon which the properties of the planetary orbits depend? Following out this line of investigation he was led to conceive the law of universal gravitation and to conjecture that the force of attraction between two bodies was directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

This law was simple enough. Could it be tested? Could it be applied in the derivation of the laws of planetary motion? Newton found that the laws of Kepler could be derived from his theory of gravitation. On the other hand it was also possible to derive his theory from Kepler's laws. The Greek theory of conic sections again played an important rôle in these discoveries. This was another fruitage of the ancient sowing.

It thus appears that speculations which were engaged in by the early philosophers solely from intellectual delight in them, became the corner-stone of the explanation of the Universe afforded by Newton's law of gravitation. Probably no discovery of man will ever surpass this in importance; for there is only one Universe in the large to explain, and Newton has explained this one.

The discoveries of Newton became the basis of the beautiful and extensive science of Celestial Mechanics. The general theory was first presented from a single point of view by Laplace in his *Mécanique Céleste*. As stated at the beginning of the first volume of this work, it was the author's purpose to "offer a complete solution of the great mechanical problem presented by the solar system, and to bring theory to coincide so closely with observation that empirical equations should no longer find a place in astronomical tables." His success in both respects brought him very close to a realization of his lofty ideal. He built his own researches and that of his contemporaries and predecessors into a magnificent explanation of the system of the universe. As so often happens, when a great work is finished, many years passed before essential additions were made to the theory; men were engaged in mastering it, in supplying its lacunae and developing to a further extent some conclusions contained in it. The late Henri Poincaré in his *Nouvelles Methodes* has in recent years made a notable and essentially new contribution to the theory. In all of this the theory of Newton is fundamental.

Let us return to the classic work of Laplace. The principal part of this, consisting of the first four volumes, was completed in the early years of the nineteenth century. This treatise holds a unique place in the history of science. It was the first instance in which a unified and logical theory (of such extent and importance) had been developed for a large class of observed phenomena. A very few fundamental principles lay at the basis of Laplace's entire work; and it was developed from these in its entirety solely by logical (that is, mathematical) processes. In such a body of truth there is something esthetically satisfying in a high degree. It could not fail to have a profound effect on the development of thought.

In fact, Celestial Mechanics became at once the model for the exact sciences. Men sought to give to other theories an equally beautiful and logically consistent form. The start from a few simple principles, easily enunciated and readily comprehended; the forward march of theory into new fields, comprising in the range of its explanation an ever-increasing portion of observed phenomena; and its ultimate comprehensiveness in this respect—these things gave it a hold on the imagination. It thus became a profound factor in the development of the whole of physical science in its mathematical form.

One has only to observe the remote origins of these theories to see what a profound rôle in scientific progress is played by the ancient Greek conic sections.

But there is still more to be said; it is becoming increasingly difficult to follow our thread, but still we shall be able to trace it further if we look carefully. We have just seen that the form of mathematical physics has been largely determined by that of Celestial Mechanics. Now experimental and theoretical physics have been profoundly influenced by mathematical speculation, both as to the direction of progress and as to the content of the discoveries.

In particular, Maxwell's theory of electricity and magnetism could not have been developed when it was and as it was without making essential use of mathematical physics. In fact, it is itself primarily a branch of mathematical physics.

Maxwell's theory, as is known to every student of science, has been a powerful element in leading to the recent advances in experimental physics. Some of the facts predicted in it waited twenty years for verification in the laboratory. Many conclusions reached in a speculative way were suggestive of new experiments; and these have been carried out—with essential addition to our knowledge of the nature and properties of electricity. It would be hard to overestimate the importance of Maxwell's work to the modern theory of electrons and that whole body of facts connected with them which give distinction and glory to the discoveries of the past few years.

Looking back now over our completed historical sketch we see that if all these developments had come without the ancient Greek theory of conic sections they must have come in an essentially different way. What are the consequences of this fact? That they actually came thus is probably sufficient evidence that this was the readiest way, and also the best for a mind constructed as ours is. From this we may conclude that if these discoveries had been made otherwise they would have been later in coming. But we have no assurance that they would ever have been made at all. When we notice to what extent it appears that discoveries are made by chance and how often an accidental juxtaposition of thoughts leads to the detection of a new principle, we feel that it would be hazardous to miss one link from the chain of scientific progress. We have not yet learned how to systematically explore new territories of thought. We can only

look over the field at random and hope to find here and there a pearl of great worth. On this account we cannot afford to lose anything which assists us to success. Every help, however remote, is essential; and we must hold it precious in our sight.

It would be foolish for us to conclude that modern physical science is a consequence of the old Greek mathematics. Many elements of diverse origin have entered into its structure—of philosophical speculation, of mathematical analysis, of experimental observation—and each of these has played an essential rôle. None can be omitted without marring or even destroying the whole.

Modern science is a web woven of threads from many sources, of which one is the Greek theory of conic sections. This thread is essential. Many others have a like place of importance, and all of these have the same claim to recognition. For the sake of definiteness we have put the emphasis upon one alone, because we have sought to trace out in one direction the value of a certain ancient speculation.

And we have indeed followed it out in only one direction. If we should seek to examine further the value of this same theory of the olden time, we should first have to observe that numerous threads of history spring from the same source. We have considered only one, and that perhaps not the most important. It would next be necessary to take up each of the others in their turn and find how they lead us into some important modern theory—whether of geometry or mathematical analysis or physical science or even philosophy—and see how they are thus woven into widely diverse parts of our present body of knowledge and opinion.

It is only when all of these have been considered in detail that we should be able to realize the magnificent consequences which owe to this ancient speculation an essential element in their development. Could those thinkers of the past have anticipated this glorious fruitage of their labors, with what a spirit of enthusiasm would they have performed their researches!

But the whole tale is not yet told. Further advances are yet to be essentially dependent upon this same fundamental basis. When one realizes the wide ramifications of the influence of research, once it is done, what greater incentive can one have to strive for the advancement of human knowledge—either directly by his own research or indirectly by his teaching others who shall

some day devote themselves to the conquest of the unknown!

The above discussion has an important corollary which we shall now state. It has to do with the problem of apparently useless research—especially in the realm of the mathematical sciences. There must be a large part of the science of every generation for which that generation knows no other use than the esthetic pleasure in its contemplation. What should be our attitude toward this part of the research of our contemporaries?

Let us recall that many generations came and went between the time of ancient Greek speculation and the gathering of the first fruitage in the researches of Kepler. But time has shown that the value to man of that early work was immeasurable; already we reap an abundant harvest. This is not an isolated case in the history of research. In fact, it is typical of a normal development. It is the way of science to burst into magnificent flower in unexpected places. We can never foresee its possibilities.

Consequently, we must treat every advance in permanent knowledge as a precious contribution to the wealth and worth of mankind, and must support it with our enthusiastic interest. America has not yet learned this lesson as she should and must learn it. The teachers of our country are to induct our people into a proper appreciation of the constructive thinking done among us.

The example which we have given is sufficient to show that future ages will remember gratefully the work which is accomplished under such encouragement.

It would doubtless be easy to find other illustrations to indicate the like value of researches in every field of scientific activity.

II.

An historical account of the past and distant is of no value to us unless we can bring it down into the here and now. Then let us ask what questions are suggested by, and what lessons are to be learned from, the history which we have reviewed together?

Consider the general subject which you are teaching today. What are the important threads of history with which the subject is shot through at the present time? What are those which came up from the past? and what are they which are just now making their appearance?

Of all these, which should be taught to a student at a given particular stage of his development—say at the stage at which you teach him?

These questions it is difficult to answer in the wisest way. The Greek theory of conic sections was studied and kept alive from generation to generation although the only reason was the esthetic delight in it. Can any one regret that it was so? In our day there is a great clamor for the practical—and the practical no doubt should be had. How much of the other should be retained? This generation is going to have to answer that question anew. Indeed, it is already thrust upon us. I am one who believes that we shall answer this question wisely only when we have studied it in the light of a profound knowledge of the forces which have heretofore determined human progress.

The glorious past must be our schoolmaster in the present—but it cannot be our taskmaster. We are living in a day of progress. I have no sort of notion that the great things were all done in the past; nor even that the most fundamental problems were all proposed. We shall ask far-reaching questions and shall also do notable things in our day and generation. The lesson of the past, however glorious, is not that we shall do the things of the past. It is rather that we shall do what seems to us good as the fathers did what seemed to them good.

We must solve anew for our generation many of the problems which the fathers solved for theirs. We have their example to inspire; but their results we can accept only as tentative. We must study out the questions anew for ourselves.

To take a special case, let us ask: What threads of mathematical history and mathematical knowledge are to be woven into the warp and woof of our young people's education? The scientific story which we have studied together shows the vast importance of our answering this question rightly. No less a matter is involved than the future progress of human thought. But it is obvious that the question is a difficult one. There are others similar to it of like difficulty and importance; every field of study affords one.

We have come upon a period of unrest. Nothing scarcely is accepted as established beyond question. The reasons for teaching every subject and every topic in each subject are undergoing critical scrutiny. This is evidenced by the large number of recent text-books and their varying content as well as by the frequent

and interested discussion among thoughtful teachers everywhere.

Many of our problems we have to solve again.

It is good for us. It is the only way to be progressive. No human being can ever do a thing so well that some other human being may not do it better. In the march of progress there is no room for the man who always wants to let well enough alone. That has been the attitude of monkeys; and it is one reason, I suppose, why they have never become men.

Nature hates a standpatter, and she never allows him the greatest success. We must always be taking hold of our questions—even the oldest ones—as if they have not been answered. It was refreshing to hear the illustrious Poincaré, a few years before his lamented death, ask in earnest whether the earth actually moves around the sun.

To settle the questions, old and new, which now confront us will require the combined wisdom of all of us.

At the present time it is hard to give a satisfactory reason why some subjects in our curricula should be there; it is harder still to see why others are excluded. Our generation is to witness a revision of courses of study which will make such a statement no longer possible. We want to gather all the threads of history out of the past, we want to find all those which are being spun today; then we must examine them, enquiring which of them can be used to best advantage in weaving the most beautiful and enduring fabric of modern civilization. These must be conserved, these must be wrought into human character through the processes of education.

For this to be done promptly and efficiently we need to bring out into the open light of free discussion our opinions, our practices and our arguments. It is a time for frankness; not merely the frankness which readily confesses all, but the frankness which finds opportunity to declare all. It is important that I know promptly and accurately what you think—what you think about your own work and what you think about mine. We need to see this whole matter from as many different angles as we have individual workers. We need also to see it from the point of view of intelligent men and women who are not professionally engaged in education. There is no other wisdom in a community so great as the combined wisdom of the whole community. It is this which we need in the solution of our present problems.

In order to get at our combined wisdom we shall need to

deliberate together. We require also to find some means of bringing our communities together for counsel. This latter in itself is a revolutionary proposal; but it is one which has been made by several persons who have approached our great modern problems from widely different points of view. We need to develop a public opinion in education which shall be virile and just. This opinion must be guided and developed by those who know the history of human thought and the needs of the present hour.

For the solution of our educational problems we also require suitable places of publication in which to record our more important ideas. America perhaps has fewer of these in proportion to the magnitude of her problems than any other of the greater countries. For those engaged in the teaching of mathematics there are two journals which stand out as especially valuable—SCHOOL SCIENCE AND MATHEMATICS and *The American Mathematical Monthly*. It is important that these journals receive the cordial and hearty support of teachers.

It is further necessary that the general discussion of our problems be examined by a large number of those engaged in educational work. The more thoughtful and valuable parts of this discussion are to be found regularly in the two journals mentioned. I want to urge teachers of mathematics to read both of these journals and all science teachers to read the former.

It is important not only that you shall know the opinions of others but also that you shall express your own—several of you no doubt in the permanent form of printed papers. It is thus that we shall disseminate most widely our varying opinions and contribute most to the early solution of our problems concerning the curriculum.

We are at the dawn of a new era in the teaching of mathematics, and probably of all the sciences. We must gather into the warp and woof of our courses other threads than those which have heretofore been woven in. The future is big with the possibilities which the present foretokens. I know that you also are inspired with the forelook of human progress. No other attitude is possible when we contemplate the magnificent achievement in the past through labors in every respect parallel to our own. It is beautiful to be comrades on such a road of progress; and I for one wish that our comradeship might grow more intimate.

SEQUENCE OF SCIENCE AND AGRICULTURE IN THE HIGH SCHOOL.[1]

By Josiah Main,

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Of all the questions to which educational committees and journals have been devoted, the problem of what the high school sciences shall be, and the order in which they shall be given, shows least progress toward final agreement. The two phases, what they shall be, and where each shall go, are so related that they cannot be considered separately, for while we are fixing the one, we find that we have disarranged the other. The problem is complicated by the introduction of a third unknown factor of how the sciences shall be affected by the introduction into the high school of industrial subjects, such as agriculture, which includes many applications of science. And it should be stated that no debate of this subject can be very profitable that does not include in the premises an agreement as to what sciences should be undertaken below the high school.

High School mathematics has a logical sequence that admits of little variation. History has a chronological sequence which must be observed, at least within its larger units; and literature has a genetic sequence which finds its counterpart in the development of the child. The science group, on the contrary, is split into distinct sciences, each of which in the hands of its specialist and advocate, contends for the place of vantage in the latter part of the course, where all the others may contribute to its dignity by preparing its way and making straight its paths. Thus, for example, botany and chemistry are each politely saying to the other, "after you." Meanwhile, the result of this internal disagreement is to break the unity of science, thus greatly impairing the value of each division, while weakening the ability of the whole group to properly assert itself amid the larger claims of the several groups.

The "unity of science" implies a dependence between different sciences which will usually be found to be mutual and argues equally well forward or backward. One method of compromising conflicting claims for precedence is to divide a science into two portions, the elementary to be given in the first year or earlier as an introductory science, and the advanced phase placed in the last year of the course. This method is specially suited to such

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a science as physics, whose rapid growth in recent years has accumulated more subject-matter than the average high school can properly treat in a year. Such a proposition is suggested in the report adopted by the secondary department of the National Education Association in July, 1911, on "The Articulation of High School and College." In its report of 1893, the Committee of Ten suggested a similar treatment of the subject of physical geography, a recommendation that seems to have had little influence on subsequent practice.

Despite the variety of opinion as to what the sequence of high school science should be, experience has established a generally accepted order, agreeing more or less with the authoritative report of the Committee of Ten. Recent high school courses of study of the twenty-one largest cities in Illinois, omitting Chicago and its environs, give interesting data concerning the present practice. The method of using this data was to give the value .5 to a science offered any time in the first year, 1.5 if offered in the second, 2.5 in the third, and 3.5 in the fourth year. For each subject, the value was taken as determined by the printed course, and the sum of the twenty-one values divided by twenty-one to find the average. Thus should each offer a particular science in the first year, the average would be a value of .5; but should any offer it at a later date the effect would be to raise that value an amount agreeable to the year in which found, subject to the reduction due to averaging. The averages thus obtained for the six sciences susceptible to this treatment were as follows:

Physical Geography	.75	Zoölogy	1.85
Physiology	.94	Chemistry	2.95
Botany	1.45	Physics	3.00

The order given in the table is the prevailing order in these schools, the chief value of the table being to show the relative, rather than the actual positions. For it is apparent that the natural tendency to vary is restricted within the limits 0 and 4, the beginning and close of the high school course, with the result that reducing a science from the high school into the grades inequitably destroys its influence on the average; and that intermediate values may result from averaging extremes as well as means, while all averages tend unduly toward the middle value 2.

The figures should also be interpreted in the light of a statute requiring physiology to be taught in the first year of the high school, and another which requires geography and physiology of

all candidates for teachers' second grade certificates, all the remaining sciences but chemistry being required for the first grade certificate.

In an investigation of forty-eight high schools "principally in the Middle West," Miss Ada L. Weckel, *School Science and Mathematics,* May, 1911, obtained data which gives almost the same sequence, though not the same values for these subjects, the only difference being that physiology, probably because it is not so firmly bound in place by statute in other states as in Illinois, has migrated to a position between botany and zoölogy. Mr. E. E. Ramsey, *School Science and Mathematics,* December, 1911, in a similar investigation of the high schools of Indiana and other states of the Middle West gets corroborative results.

The recommendation of the Committee of Ten concerning geography was that the more elementary portions constitute the "physical geography" of the first year, while the more technical portions be carried over to the last of the course. Though no school was found to divide the subject for an elementary and an advanced treatment they generally agree with the recommendation by placing it in the first year, variations from which showed a tendency to carry it over to the last year.

No recommendation of the committee has been more generally observed in practice than the one placing botany and zoölogy in the second year. However, these two subjects, at first closely associated, show an unmistakable drift from their moorings, botany moving downward toward the first year, as shown in Miss Weckel's investigations, and zoölogy moving toward the third year or being eliminated. Botany is subjected to two opposing influences which will probably divide it into two distinct portions. The introduction of agriculture below the high school is already resulting in the injection of much elementary botany into the elementary grades, while the leading botanists insist on giving high school botany a character that would move it in the other direction. The migration of zoölogy to the third and fourth years to be followed by physiology, as located by the Committee of Ten would make possible an evolutionary treatment of the combined subject that is much to be desired.

The recommendation of the Committee regarding physics and chemistry has not been respected. It will be recalled that the conference to whom the Committee assigned those subjects recommended a placement identical with the one now prevailing; but owing to their division of physical geography into an

elementary and an advanced portion, the Committee reversed that order so that physics might precede and prepare for the advanced work in physical geography. The reason for this reversal not proving well founded, the recommendation of the conference should prevail. This would agree with the present evident tendency to relieve the physics difficulty by putting its elementary phases into a first year science course and leaving the more technical and quantitative treatment for the last year of the course.

The proverbial inertia of school curricula makes unsafe any *laissez faire* method of establishing the sequence of high school sciences. But it must not be thought that the present sequence is to any considerable extent the result of neglect. What then are the influences that have established this order of treatment?

Doubtless authoritative recommendations of competent committees have been a strong influence; also the accrediting system of colleges and universities by requiring a certain character of work offered in admission, have indirectly determined its location in the course. And an increasing complexity and supposed dependence of subjects has been a component of the final result. The tendency to place general and prescribed courses before special and elective courses has been a strong influence. Other temporary causes are the supply and demand of scholarship in high school teachers and their preparation in the different sciences, and the relative expense of equipment which the different sciences demand. Finally to be mentioned as a powerful factor is the recency of introduction of the various sciences to the course. All subjects shown in the high school course have entered it from above, having been handed down from the colleges, and tend to gravitate from the latter part of the course toward the earlier until they find their supposed level in youthful capacity. Thus chemistry, the most recent introduction, has probably not yet exhausted its downward tendency.

Yet the foregoing influences are all more or less superficial and transient. Deeper than them all is a rational motive that has sometimes found its expression through them and should ultimately control the sequence of science in the high school.

With the young the learning process involves a great deal of muscular reaction. This necessity of motor expression diminishes with advancing years and the accumulation of an interpretive stock of motor experiences with things. The size of the muscles involved in these reactions is an index of the stage of develop-

ment of the learner. And since the accuracy and promptness of every muscle seems capable of unlimited improvement by education, they, too, indicate stage of development. On final analysis, the correct gradation and sequence of all rational school subjects will probably be found to conform to muscular development. The difficulties in high school sciences inhere largely in the formulae with which the teacher short circuits his explanations or the verbiage with which he covers his ignorance. Whatever is definite is easy. Uncertain or confused things only, are difficult, and anything worth knowing may be taught the adolescent by a competent teacher.

Applying this test of motor adjustments, a solution of the problem of high school science will at the same time determine the correct sequence of the different phases of agriculture in the schools. All of the subjects involve the use of both the large and small muscles. Subjects demanding more use of the finer muscles go later in the course than those involving more use of the coarser. Those requiring skill and accuracy of the larger muscles may often have an early or late treatment, or both. First year high school students are familiar with or may make all of the adjustments demanded by such work as geography, soils, stream action, farm machines, and elementary physics. Tillage, the study of the corn plant and ear, the morphology of root, stem, and leaf, and budding, grafting, pruning, and spraying involve motor adjustments appropriate to the grammar grades. The examination of cells, fibro-vascular bundles, and the stamens and pistils of most plants, and the making of biological drawings—work which exercises the finer muscles of accommodation—the preparation of slides and the adjustment of the microscope do not belong below the second year of the high school. And correlated with the botany may appropriately be placed budding, grafting, spraying, and pruning in a more rational form and demanding a higher grade of skill. School gardening exercising as the work does, the larger body muscles, is appropriate to the primary grades. Nature study may be regarded as the most appropriate muscle culture known to the schools in that it automatically adjusts itself to the stage of development of the pupil. Until someone defines more definitely than has yet been done the character of animal husbandry best suited to the schools that subject may go anywhere in the course. When the need and the opportunity for the drawing of correct animal conformation is appreciated, it will be given an advanced position. Exercises in advanced physics, de-

mand delicate adjustments appropriate to the last year of the high school course which position also agrees with the mathematical requirements of the subject. Accurate use of dissecting instruments, the fine balance, fragile glassware, and c. p. reagents, and the making of a pure culture and keeping it pure, demand muscular skill not to be found below the third year of the high school course.

Influenced by this factor the high school sciences will find their places and the sequence of the different phases of agriculture that are naturally correlated with them will, by the same process, have their positions determined.

HAWAIIAN SCHOOLS.

Japanese pupils now form the most numerous element in the Hawaiian schools, and they are increasing at a more rapid rate than any other race, according to a statement by Governor Walter F. Frear, received at the United States Bureau of Education. The Japanese now have a considerable lead in the school population, with over 31 per cent of the total; the Portuguese follow with a little less than 17 per cent; the Hawaiians come next with 14 per cent; Part-Hawaiians comprise 14 per cent; Chinese, 11 per cent; and all other nations or races, 12 per cent.

Governor Frear gives other interesting information about Hawaii's schools. He shows how, after the establishment of the Territorial Government in 1900, the public schools fared worse and worse until 1907, when, with increasing prosperity for the islands, more ample provision was made for education. Finally, in 1911, a new method of financing the schools was adopted, under which there has been a decided gain in the number of teachers, in salaries, and in general efficiency.

Industrial schools that are partially self-supporting are a feature of the Hawaiian school system. There are three such schools, and in addition, the Normal School, the College of Agriculture and Mechanic Arts, two high schools, and 151 schools of elementary grade. A number of the schools maintain city or country governments conducted by the pupils for practice in citizenship, and patriotic exercises are emphasized in all the schools.

There are now nearly 30,000 children in the Hawaiian schools, about twice as many as there were at the time the Territorial Government was established, twelve years ago. The territory last year spent $582,536 for education, and the counties themselves $47,799 additional. These figures are exclusive of expenditures for the College of Hawaii, which now occupies a permanent site in the suburbs of Honolulu and has graduated its first class.

The Hawaiian schools are up to the American practice in length of term; their school year is 38 weeks. Attendance is compulsory from six to seventeen years of age, the maximum age having been raised from fifteen a year ago. Good attendance records are the rule; the average last year was 86 per cent of the enrollment. In this and other respects the schools of Hawaii compare favorably with the best in the United States.

AN EXPERIMENT IN SCIENCE TEACHING.

By Floyd L. Darrow,
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All teachers of science may be assumed to have at least some problems in common. While these problems will present varying degrees of difficulty to different teachers and will not apply with equal force to all science subjects, yet there is one which several years of experience in public and private schools, both East and West, leads me to believe is a paramount problem in practically every school. Although variously designated as lack of interest, the difficulty of getting pupils to work, indifference to scholarship, etc., it resolves itself into the problem of teaching pupils how to study.

Poor recitations are due not so much to the lack of time and effort in the preparation of lessons as to the fact that the pupil does not know how to study. Often even more time is devoted to preparation than ought to be necessary, and too, with very unsatisfactory results, simply because the pupil has no working knowledge of correct methods of study. In questioning a boy recently as to his method of attacking a lesson he replied: "I read the lesson over. "And what then?" "I read it over again." "And then?" "I read it over again." Upon being asked his purpose in this, he replied that it was with the hope that some of the facts might "stick" until after recitation. Whether teachers realize it or not, very much of the poor class room work must be attributed to just this sort of study. Although every pupil who reaches the senior grade of the high school should possess the power to analyze a paragraph and learn the important facts contained in it, yet it is undeniable that a large percentage of high school pupils are unable to do this. Since education has for its object training for power—power to tackle problems and solve them—unquestionably all grade and high school teachers should realize much more keenly this fundamental problem of teaching pupils how to work.

My subject is chemistry and when a boy enters my class in his junior or senior year without the ability to master a lesson in a reasonable length of time, I cannot devote all my effort to giving him the training which he should have received earlier in his school career. But since I am responsible for his success or failure in State and College Board examinations, neither can I allow him to drift on with his faulty habits of study. Of

course, I fully realize that science subjects through laboratory work and class demonstrations afford a basis for questioning and first hand information not possessed by many other subjects. However, there is a large body of facts that must be acquired by reading and definitely assigned lessons from some standard text. In this work it has been my experience that a pupil will come to class with abundant evidence of having "spent time" on the lesson but with no satisfactory digest of its significant facts. He has spent as much time on the unimportant details as he has on the fundamental parts of the lesson. He lacks the power to sift out and assimilate the vital parts. With more time allotted to science subjects so that their facts might be presented largely by first hand laboratory work and class demonstrations followed by thorough class discussion, the problem would be somewhat simplified. But even then we could not eliminate the necessity of assigned lessons, for it is manifestly impossible to teach all the necessary facts, the theory and practical applications of the subject in the foregoing way.

In my efforts to solve this problem of teaching pupils how to study no other plan, that I have ever tried, has succeeded so well as the one which I am following this year. I give to each pupil a mimeographed copy of questions on the lesson assigned for the following day in which I make very definite what he is to learn. I emphasize the important things and pass lightly over those of less weight. The method enables me to bring out the lesson in its proper perspective. It analyzes the lesson for the pupil and shows him just exactly what is expected of him. The questions are such that the pupil must read the text and reference books thoroughly and many of them call for discussion and not a mere memorizing of facts. In this way I am able to cover the work more quickly and effectively, for the energy spent both in class and out of class is directed toward definite ends. The pupil finds the preparation of his lesson an easier and more logical matter. He begins to know what is important and what is unimportant in the subject matter of the text. He is gaining the power to analyze for himself. On each sheet of questions I usually give several in review and these together with the frequent use of the original questions for review purposes keep the early parts of the subject fresh in mind. By making the questions cover laboratory work and class demonstrations as well as the text the whole range of work is covered in a very effective way. Since the adoption of the plan, the

quality of class recitations has improved very markedly. The members of my classes are unanimous in their approval of the method—not only because it simplifies the preparation of their lessons but because they feel that they are getting the subject much more thoroughly.

Of course this plan is open to objections. It may be urged that to analyze the pupil's lesson for him is to perform a most important part of his task and thus rob him of the power to be derived from doing it himself. This may be true, but if the pupil is utterly unable to perform this part of his task there can certainly be no harm in doing it for him in such a manner as to teach him eventually how to do it for himself. Very frequently teachers assume that pupils should know instinctively what are the important points in a lesson when they really have no basis for determining them. Pupils in taking up a new subject must have some direction in the preparation of lessons and I believe that the method described gives this guidance effectively and with the greatest economy of time and effort. The continued use of this method does not, as some may suppose, make the pupil dependent upon it, but rather teaches him to tackle a lesson and master it with a minimum expenditure of time and energy. By occasional assignments of lessons without questions his power in this direction may be tested and trained. Neither does the assignment of definite questions restrict or hamper the freedom of class recitations. The instructor may use the substance of these questions as the basis of the class work but it is unnecessary to put the questions in the exact form and order in which they appear on the question sheet. If the pupil has properly prepared his lesson he will be able to answer any reasonable question put to him. But, perhaps, the greatest obstacle to the use of this plan is the large amount of work which it necessitates for the teacher in the preparation of questions. For my own use, however, I am preparing a small book of questions and problems following by lessons the text which I use and including several sets each of state, college board and college entrance examinations. This I shall have printed and shall sell to the members of my classes at a price sufficient to pay for the cost of printing.

The object of this method is to develop greater power on the part of the pupil, to eliminate waste energy and to secure better results because of well directed effort. But related to this problem of developing correct habits of study is the vital one of

interest without which any method however good in itself, will be of little avail. Were it not beyond the scope of this paper, I should be glad to discuss some of the means employed to make the pupil feel that the subject of chemistry touches life at innumerable points and to arouse his active interest in it. I will therefore merely mention several, as an active science club, demonstrations with such striking things as liquid air, thermit welding, oxyhydrogen blowpipe and electric furnace, laying emphasis upon industrial chemistry, visiting industrial plants, getting pupils to do extra work in the laboratory as setting up apparatus to demonstrate to the rest of the class some process, preparing salts and simple organic compounds, making alloys, doing work in simple analysis.

That the reader may gain a better idea of the sort of questions asked on these question sheets I will append a few on the subject of hard and soft water.

1. What was the original significance of the terms "hard" and "soft" as applied to water? Their present chemical significance?

2. Name two kinds of water that will be soft and two that are apt to be hard. What is the essential difference between these two classes of water?

3. Name the two kinds of hardness with the reasons for thus designating them.

4. To what compound present in water is temporary hardness due? Account for the presence of this compound in natural waters.

5. Describe two methods for the removal of temporary hardness. In each case write the reactions. What ion has been removed from solution by both of these processes? Since the water has been softened, to what then must its hardness have been due?

6. To what compounds present in water is permanent hardness due? Account for the presence of these compounds in water.

7. Why cannot permanent hardness be removed by the same methods as those employed for temporary hardness? Describe a method for its removal. Write the reactions. What ions have been removed from solution by this process. To what then must the hardness have been due?

8. What is the real cause of either kind of hardness?

9. What is the chemical nature of soap? What is the effect of hard water on soap solution? What is formed by their interaction? What is the effect of soft water on soap?

10. How could you determine whether a sample of water is hard or soft? temporarily or permanently hard? Possesses both kinds of hardness? How could you determine the degree of hardness?

11. Name several industries that require soft water.

12. Design a plant for the removal of both kinds of hardness where large quantities of water must be softened.

13. What is used for softening water in the household?

Such a set of questions I let precede the class work on the subject and then accompany the class discussion with demonstrations. This is followed by individual laboratory work. I

believe that questions of this nature open the pupil's mind to ideas that would entirely escape him were he simply assigned so many pages of the text and left to himself. The method has brought real results in my own teaching and may be suggestive to others.

HIGH SCHOOL AND COLLEGE.

"Unless the American high school and the American college are adjusted, we have no real educational system," says Clarence D. Kingsley, in a bulletin on college-entrance requirements just issued by the United States Bureau of Education. In these words he sums up the current demand that the colleges of the country shall give the high schools more freedom in their work by ceasing to insist upon requirements for entrance that hamper the school in its duty to the community. He insists that the colleges recognize the changing demands in the high school and base their requirements accordingly. He objects alike to the "easy" college that admits students obviously unprepared and the institution whose demands are so stringent that none of the public high schools can reasonably meet them.

Notwithstanding recent changes in the direction of uniformity, great variety in requirements is still found. English is about the only regularly required subject. Curious contradictions appear in the several hundred institutions examined. Certain subjects are considered so important by some colleges that they require them, while other colleges will not even accept them. Thus, for admission to the A. B. course there are four colleges that give no credit for science, and four that give credit for only half a year of it, while, on the other hand, 91 colleges prescribe one full year of science. "Such contradictions as these," says Mr. Kingsley, "burden the high school, provincialize college student bodies, and discredit fine discriminations between subjects." Again, some colleges rigidly enforce the statements printed in the catalogue, while others leave much discretionary power to the officer in charge of admission.

Some real improvements in the relation of high school and college are noted, however, showing that these two important agencies in education are more willing to help each other than they have been in the past. Many colleges now accept various practical subjects for admission. Of the 203 colleges of liberal arts examined, 97 recognized shopwork, 88 commercial branches, 80 agriculture, and 79 "household science" as subjects of admission. There is a large and growing list of colleges that will accept for entrance any subject that an approved high school counts toward graduation.

That admission to college should be based solely on the completion of a well-planned high school course; that the high school should be given free play, so that it may adapt its work to the needs of the community; and that the colleges must keep the door open to the youthful seeker after a college education who is animated by a strong inner purpose in the face of obstacles regardless of whether he has fulfilled the old-fashioned formal requirement or not; these are some of the conclusions drawn by Mr. Kingsley as to the mutual duty of school and college.

COLLATERAL READING FOR HIGH SCHOOL BIOLOGY.

By T. W. Galloway,
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Introduction. In the meeting of 1912, the Biology Section of the High School Conference at Urbana agreed to take steps toward the selection of a list of the most satisfactory books to serve as collateral and reference reading for pupils in High School Biology. As a first step it was felt that a series of experiments should be undertaken, by actual teachers of High School or Preparatory Biology, in which an effort would be made to get the actual preferences of the pupils. The wish is to supplement the judgment of teachers themselves, in this respect, by whatever data may be obtained as to what has seemed to the pupils most helpful. Mr. G. J. Koons of Murphysboro, a member of the executive committee of the section, has been asked to secure the coöperation of teachers in making these experiments, and he will be glad to confer with any teachers who are willing to take part in them.

The present study was not begun until after the meeting of 1912. It is reported at this time merely with the hope that it may stimulate other tests during the present school year. The statement of it may aid some other teacher to improve the condition under which the test shall be given, and the methods of conducting it.

The Method of the Experiment. At the outset it became manifest that it would be necessary to motivate this reading in such a way as to get essentially all the members of the class interested in it so that they would read enough really to have a judgment on the subject; and, secondly, to waive the required readings usually planned for the course in order to leave the pupil's mind free and unbiased for his own enterprise.

In motivating the work the instructor made a brief talk, explaining the general purpose of the investigation and the worthwhileness of doing anything that would help make schools more effective. Attention was called to the personal growth that would come to them from doing the necessary work in a sincere and thorough way. A definite remission of certain required work late in the year was promised for those whose work was thus done.

The amount of actual outside reading was agreed upon as "not less than an average of one hour a week," from December

1st to June 1st. This, to be sure, is not enough time to insure an expert judgment, but it is scarcely possible to ask for more.

The following steps were outlined in order to give the student a somewhat catholic view of the subject, and to help insure that accident or first impressions should not have too big a place in determining the books chosen for reading.

1. Each student was required to prepare at the outset a list of not less than twenty biological topics at that time most appealing to him as interesting and important. This was prepared and handed in the first week of the test. These lists were scrutinized with some care, and were read in class with brief comments. In order that peculiarly one-sided lists might be rounded out, each student was asked to enlarge his list in the light of these various exercises.

2. Each student was asked to look over the titles, and to handle all the biological books (zoölogical, botanical, physiological, etc., were specified in the instructions) in the three libraries available: Millikin University; Carnegie Library of Decatur; and the instructor's private library.

3. The student was asked to furnish a list of the books really examined by him fully enough for him to get a fair idea of them as furnishing a basis for his final selection. It was suggested that this first list should have at least three or four times as many books in it as the final list to be handed in as the choice of the student.

4. From these preliminary lists the student was, by reading and selection, to prepare a list of ten books which for any reason seemed most worth-while to him, and most likely to prove helpful as supplementary reading for students of elementary biology. These books were to be listed in the order of their excellence, and with each was to be a brief statement of that which commended it particularly to the student.

The exercise consisted essentially in eliminating from some 300 or 400 books that might fairly be conceived as available and possessed of some elements of suitability, until a list of 30 or 40 was left; and then eliminating all but 10 of these. It is very evident that the final list in any such experiment depends very much on the number, character, and variety of books to which the student is exposed at the outset. It is also certain that the attractiveness of the title, the illustrations, and other easily appreciated elements would enter largely into the first or longer lists.

Range of Books from Which Selections Were Made. A list of something more than 100 books is given here, made up from the longer lists presented by the students. This will give some idea of the range of the books which were really seriously used in making the lists of 10. It includes all the books suggested by anybody among the first 10, and those that were enumerated as often as three times in the longer list, even though they might not be found in any final list. The order in which they appear has no significance.

1. Plant Life. Barnes.
2. Flowers of Field, Hill, and Swamp. Creery.
3. Frail Children of the Air. Scudder.
4. Wasps, Social and Solitary. Peckham.
5. Jellyfish, Starfish and Sea Urchin. Romanes.
6. Nature's Craftsmen. McCook.
7. Recreations in Botany. Creery.
8. Our Insect Friends and Foes. Cragin.
9. Familiar Flowers of Field and Garden. Mathews.
10. How to Know the Wild Flowers. Dana.
11. Flowers and Ferns in their Haunts. Wright.
12. Tenants of an Old Farm.
13. Honey Makers. Morley.
14. Mosquitoes. Howard.
15. The Individual. Shaler.
16. Elements of Zoölogy. Holder.
17. Animal Locomotion. Pettigrew.
18. Effects of Use and Disuse. Ball.
19. Plants. Coulter.
20. Animals. Jordan.
21. Locusts and Wild Honey. Burroughs.
22. Moths of the Limberlost. Porter.
23. Bird Homes. Dugmore.
24. Water Babies. Kingsley.
25. Fisherman's Luck. Van Dyke.
26. Manners and Movements of Prehistoric People.
27. Elementary Botany. Atkinson.
28. Insect Pests of Farm, Garden, and Orchard. Sanderson.
29. Heredity and Christian Problems. Bradford.
30. On the Senses, Instincts and Intelligence of Animals. Avebury.
31. New Creations in Plant Life. Harwood.
32. Birds in Their Relation to Man. Weed.
33. Animal Mind. Washburn.
34. Heredity and Eugenics. Coulter, Castle, etc.
35. Comparative Anatomy of Vertebrates. Kingsley.
36. Animals and Man. Kellogg.
37. Introduction to Zoölogy. Davenport.
38. Biology and its Makers. Locy.
39. Manual for Study of Insects. Comstock.
40. Development and Evolution. Baldwin.
41. Elementary Entomology. Sanderson.
42. Sleep. M. de Manacéine.
43. Text Book of Zoölogy. Parker and Haswell.
44. Elementary Physiology. Huxley.

45. General Principles of Zoölogy. Hertwig.
46. Romance of the Insect World. Badenoch.
47. Insect Life. Comstock.
48. Our Household Pests. Butler.
49. Study of Animal Life. Thompson.
50. Principles of Agriculture. Bailey.
51. Diseases of Plants. Ward.
52. Animal Coloration. Beddard.
53. Care of Trees. Fernow.
54. Entomology. Folsom.
55. Living Lights. Holder.
56. Play of Animals. Gross.
57. Habit and Instinct. Morgan.
58. Heredity in Relation to Eugencies. Davenport.
59. Genetics. Walter.
60. Biology, General and Medical. McFarland.
61. College Botany. Atkinson.
62. Nature Study and Life. Hodge.
63. Introduction to Zoölogy. Schmeil.
64. Bacteria, Yeasts, Molds in the Home. Conn.
65. Comparative Zoölogy. Orton.
66. Evolution and its Relation to Religious Thought. LeConte.
67. Degeneracy. Talbot.
68. Lessons in Botany. Gray.
69. American Weeds and Useful Plants. Darlington.
70. Zoölogy. Shipley and McBride.
71. Anthropoid Apes. Hartman.
72. Insectivorous Plants. Darwin.
73. Dawn of Reason. Weir.
74. Animals of the Past. Lucas.
75. Man and his Ancestors. Morris.
76. With the Wild Flowers. Harding.
77. Animal Life and Intelligence. Morgan.
78. Wonders of the Bird World. Sharpe.
79. Birds that Hunt and Are Hunted. Blanchan.
80. Principles of Economic Zoölogy. Dougherty.
81. Colors of Animals. Poulton.
82. Common Spiders. Emerton.
83. Insects Injurious to Fruit. Saunders.
84. Wonders of Insect Life. Willet.
85. Instinct and Health. Woods-Hutchinson.
86. In Nature's Workshop. Allen.
87. Food and its Functions. Knight.
88. Whales. Beddard.
89. Personal Hygiene. Bosquet.
90. Medical Inspection in Schools. Gulick.
91. Home Life of Wild Birds. Herrick.
92. Housefly. Howard.
93. Life of the Bee. Maeterlinck.
94. Principles of Sanitary Science. Sedgwick.
95. Methods of Attracting Birds. Trafton.
96. Human Ear. Ellis.
97. Wonders of Life. Haeckel.
98. Biology of the Frog. Holmes.
99. Formation of Vegetable Molds. Darwin.
100. Island Life. Wallace.

101. Diseases of Economic Plants. Stevens-Hall.
102. Guide to Butterflies. Scudder.
103. Marvels of Animal Life. Holder.
104. Renewal of Life. Morley.
105. Text Book of Plant Physiology. MacDougal.
106. Along Four Footed Trails. Cook.
107. Life and Love. Morley.
108. Types of Animal Life. Mivart.
109. Home Life of Wild Birds. Herrick.
110. Our Trees and How to Know Them. Emerson-Weed.
111. Shells of Sand and Water. Baker.
112. Comparative Physiology and Morphology of Animals. LeConte.
113. Household Bacteriology. Buchanan.
114. Botany all the Year Round. Andrews.
115. Principles of Animal Histology. Dahlgren.
116. Lure of the Garden. Hawthorne.
117. Foundations of Zoölogy. Brooks.
118. Sharp Eyes. Gibson.
119. Eye-Spy. Gibson.
120. Little Brothers of the Air. Miller.
121. My Studio Neighbors. Gibson.
122. Beasts of the Field. Long.
123. First Steps in Human Progress. Starr.
124. Primer of Darwinism. Bergen.

The Lists of Ten Books. The following list gives the titles that received as many as two votes in the lists of ten. The books are enumerated in the order of their popularity. The number in brackets is the number of votes received. There were 18 students who completed reports. Ten of these were college students; eight, preparatory. In the case of the college students I requested that they give me a separate list of those books they thought would prove most helpful to high school pupils, in case they felt that their own favorites did not constitute such a list. It is interesting that such students almost invariably selected more elementary books for the sub-freshmen users than did the sub-freshmen themselves.

1. Biology and Its Makers. Locy. (9)
2. Plants. Coulter. (8)
3. The Housefly. Howard. (7)
4. Nature's Craftsmen. McCook. (6)
5. Bird Homes. Dugmore. (6)
6. Insect Pests of Farm, Garden, etc. Sanderson. (6)
7. Romance of Insect World. Badenoch. (5)
8. Moths of the Limberlost. (5)
9. Plant Life. Barnes. (4)
10. New Creations in Plant Life. Harwood. (4)
11. Dawn of Reason. Weir. (4)
12. Insect Friends and Foes. Cragin. (3)
13. Animals and Man. Kellogg. (3)
14. Wonders of the Bird World. Sharpe. (3)

15. Animals of the Past. Lucas. (3)
16. Care of Trees. Fernow. (3)
17. Heredity and Eugenics. Coulter, Castle, etc. (3)
18. Our Trees and How to Know Them. (3)
19. Botany for Schools. Atkinson. (2)
20. Wasps, Social and Solitary. (2)
21. Text Book of Zoology. Parker and Haswell. (2)
22. Entomology. Folsom. (2)
23. Wasps and Their Ways. (2)
24. Study of Animal Life. Thompson. (2)
25. Diseases of Economic Plants. Stevens-Hale. (2)
26. Principles of Economic Zoölogy. Dougherty. (2)
27. Colors of Animals. Poulton. (2)

As might have been anticipated, the first 10 books in this synthetic group do not make a balanced list. It would not accord with the choice of any student. Each student seemed to make an effort to have the reading cover a fairly wide field. Usually there was in each list some sort of a book (often two) on insects, another on birds, two or more on some of the popular literary nature studies, one an attractive elementary text of botany or zoölogy or biology, a book on identification of trees or wild flowers, one or more "wonder" books, a book dealing with some special consideration such as coloration, degeneracy, heredity, evolution, eugenics, and the like. The individual lists were intelligently made—many of them were very good. The accompanying lists will serve as examples. The first is a little overloaded with elementary texts of botany and zoölogy, but the selections are good.

1. Plants. Coulter.
2. Animals and Man. Kellogg.
3. Physiology and Hygiene. Walters.
4. Animals, Jordan, Kellogg, etc.
5. Plant Life. Barnes.
6. Housefly. Howard.
7. Comparative Zoölogy. Orton.
8. Biology and Its Makers. Locy.
9. New Creations in Plant Life. Harwood.
10. Our Native Trees. Keeler.

Another:

1. Nature's Craftsmen.
2. Dawn of Reason.
3. Animals of the Past.
4. Wasps, Social and Solitary.
5. Insect Pests of Farm, Garden, and Orchard.
6. Man and His Ancestors.
7. With the Wild Flowers.
8. In Nature's Workshop.
9. Animal Life and Intelligence.
10. Wonders of the Bird World.

In this study the emphasis was put on *reading* and *readable* books, rather than on reference books. There was no effort made to eliminate reference books, and some students, impressed with their value, included such. This is one shortcoming of the test. Both classes of books should be *included*, and they should be *distinguished*. Furthermore, no effort was made to distinguish sharply among the various elements that might make a book worth placing on the lists. Such terms as "useful," "valuable," "interesting," "helpful," "informing," were freely and more or less interchangeably used. It is undoubtedly true that various pupils put their emphasis upon somewhat different elements of value. This, in part, accounts for the wide diversity in the lists. The composite list, however, of a larger number of pupils would tend to correct this and to unify the emphases. While I think the fusion of these elements is desirable in forming a list of books, it is possible that tests in which emphasis is separately put on the interesting, and useful, and informing qualities might be worth while.

A SCHOOL FOR THE DISCONTENTED.

There is a school for discontented school children in Kansas City, Missouri, according to information received at the United States Bureau of Education. The "Lathrop Industrial School" has been organized for the purpose of educating children over 14 years of age who have reached the fifth grade and find the work of the regular school distasteful.

The school proceeds on the theory that in many cases the distaste of these children for school is due to the fact that the ordinary studies are not adapted for their particular needs. Such pupils frequently appear "backward' or lazy, when in reality all they need is a different form of educational activity. Accordingly, Lathrop school gives them what is known as "prevocational" training. Courses in bench woodworking, shop drawing, pattern making, printing, carpentry, and shop electricity are provided for the boys; cooking, sewing, millinery, and embroidery for the girls. Classes in plumbing, bricklaying, and concrete work will be formed as soon as the demand warrants.

The acadamic branches are also taught in this continuation school, but they are taught in close relation to the industrial subjects. Arithmetic concerns the problems of the shop. English consists of practical instruction in necessary business forms; no attempt is made to teach technical grammar. Geography and history are taught from the commercial standpoint; and local government is an important subject.

The course is three years. During the first two years the teacher directs the choice of the pupils; but for the last year each boy is allowed to select his work in the trade he wishes to learn. Time is about equally divided between industrial and academic branches.

LIST OF PUBLICATIONS OF THE CENTRAL COMMITTEE AND THE NATIONAL SUB-COMMISSIONS.[1]

PUBLICATIONS OF CENTRAL COMMITTEE.

Publications of the Central Committee, 1st series; 1908-1911, edited by H. Fehr, General Secretary of the Commission. 1 vol. 200 p. 5. fr.

1. *Rapport préliminaire* sur l'organisation de la Commission et le plan général de ses travaux (*Ens. math.*, nº de nov. 1908). [16 p.]

2. *Circulaire nº 1:* Constitution de la Commission.—Sous-commissions nationales (*E. M.*, nº de mai 1909). [12 p.].

3. *Circulaire nº 2:* Nouveaux membres.—Sous-commissions nationales. —Etat des travaux au commencement de 1910 (*E. M.*, mars 1910). [16 p.].

4. *Circulaire nº 3:* Réunion de Bruxelles. Compte rendu des séances de la Commission et des conférences sur l'enseignement scientifique et sur l'enseignement technique moyens faites à Bruxelles du 10 au 16 août. Conférence de M. C. BOURLET sur la pénétration réciproque des mathématiques pures et des mathématiques appliquées dans l'enseignement secondaire (*E. M.*, nº de sept. 1910). [63 p.].

5. *Circulaire nº 4:* Etat des travaux au 1er mars 1911 (*E. M.*, mars 1911). [16 p.].

6. *Circulaire nº 5:* Compte rendu du Congrès tenu à Milan du 18-21 septembre 1911 (*E. M.*, nº de nov. 1911). [75 p.]:

Rapport de la Sous-commission A: 1. la question de la rigueur dans l'enseignement moyen; 2. la fusion des différentes branches mathématiques. —Annexe: Note de M. YOUNG (Chicago).

Rapport de la Sous-commission B: L'enseignement mathématique destiné aux étudiants en sciences physiques, en sciences naturelles, etc.

Sull'insegnamento matematico nelle scuole per gli ingegneri. Par le Prof. COLOMBO.

Mathématiques et Théorie de la connaissance. Par le Prof. F. ENRIQUES.

GERMANY.

A. Berichte und Mitteilungen

veranlasst durch die Internationale Mathematische Unterrichts-Kommission. Herausgegeben von W. LIETZMANN. In zwanglosen Heften. gr. 8. Steif geh. (B. G. Teubner, Leipzig).

I. FEHR, H., Vorbericht über Organisation und Arbeitsplan der Kommission. Deutsche Uebersetzung von W. LIETZMANN. [S. 1-10.] 1909. M.—30.

II. NOODT, G., über die Stellung der Mathematik im Lehrplan der höheren Mädchenschule vor und nach der Neuordnung des höheren Mädchenschulwesens in Preussen. [S. 11-32.) 1909. M.—.80.

III. KLEIN, F., und H. FEHR, erstes Rundschreiben des Hauptausschusses. Deutsch bearbeitet von W. LIETZMANN. [S. 33-38.] 1909. M.—20.

IV. KLEIN, F., und H. FEHR, zweites Rundschreiben des Hauptausschusses. Deutsch barbeitet von W. LIETZMANN, sowie P. ZÜHLKE, Mathematiker und Zeichenlehrer im Linearzeichenunterricht der preussischen Realanstalten. [S. 39-54.] 1910. M.—.50.

V. LIETZMANN, W., die Versammlung in Brüssel. Nach dem von H. FEHR verfassten dritten Rundschreiben des Hauptausschusses. [S. 55-74.] 1911. M.—.60.

VI. FEHR, H., Viertes Rundschreiben des Hauptausschusses. Deutsch bearbeitet von W. LIETZMANN. [S. 75-88.] 1911. M.—.50.

VII. LLETZMANN, W., Der Kongress in Mailand vom 18. bis 20 Sept. 1911, sowie SCHIMMACK, R., Ueber die Verschmelzung verschiedener Zweige des mathematischen Unterrichts. [S. 89-126.] 1912. M. 1.60.

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[1] These reports may be obtained from Librairie Georg and Cie Geneva, Switzerland.

B. Abhandlungen

über den mathematischen Unterricht in Deutschland, veranlasst durch die Internationale Mathematische Unterrichts-Kommission. Herausgegeben von F. KLEIN.—5 Bände, in einzeln käuflichen Heften. gr. 8. Steif geh. (B. G. Teubner, Leipzig).

ERSTER BAND—**Die höheren Schulen in Norddeutschland.** Mit einem Einführungswort von F. KLEIN.

1. Heft: LIETZMANN, W., Stoff und Methode im mathematischen Unterricht der norddeutschen höheren Schulen auf Grund der vorhandenen Lehrbücher. [XII u. 102 S.] 1909. M. 2.—.

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3. Heft: LOREY, W., Staatsprüfung und praktische Ausbildung der Mathematiker an den höheren Schulen in Preussen und einigen norddeutschen Staaten. [V. u. 118 S.] 1911. M. 3.20.

4. Heft: THAER, A., N. GEUTHER und A. BÖTTGER, Der mathematische Unterricht an den Gymnasien und Realanstalten der Hansestädte, Mecklenburgs und O'denburgs. [VI u. 93 S.] 1911. M. 2.—.

5. Heft: SCHRÖDER, J., Die neuzeitliche Entwicklung des mathematischen Unterrichts and den höheren Mädchenschulen, insbes. in Norddeutschland. (Unter des Presse.)

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2. Heft: WITTING, A., Der mathematische Unterricht an den Gymnasien und Realanstalten nach Organisation, Lehrstoff und Lehrverfahren und die Ausbildung der Lehramtskandidaten im Königreich Sachsen. [XII u. 78 S.] 1910. M. 2.20.

3. Heft: GECK, E., Der mathematische Unterricht an den höheren Schulen nach Organisation, Lehrstoff und Lehrverfahren und die Ausbildung der Lehramtskandidaten im Königreich Württemberg. [IV u. 104. S.] 1910. M. 2.60.

4. Heft: CRAMER, H., Der mathematische Unterricht an den höheren Schulen nach Organisation, Lehrstoff und Lehrverfahren und die Ausbildung der Lehramtskandidaten im Grossherzogtum Baden. [IV u. 48 S.] 1910. M. 1.60.

5. Heft: SCHNELL, H., Der mathematische Unterricht an den höh. Schulen nach Organisation, Lehrstoff und Lehrverfahren und die Ausbildung der Lehramtskandidaten im Grossherzogtum Hessen. [VI u. 51 S.] 1910. M. 1.60.

6. Heft: HOSSFELD, Der mathematische Unterricht an den Gymnasien und Realanstalten Thüringens nach Organisation, Lehrstoff und Lehrverfahren. [ca 20 S.] 1912. M. 0.80.

7. Heft: WIRZ, J., Der mathematische Unterricht an den höheren Knabenschulen sowie die Ausbildung der Lehramtskandidaten in Elsass-Lothringen. [VI u. 58 S.] 1911. M. 1.80.

DRITTER BAND—**Einzelfragen des höheren mathematischen Unterrichts.** Mit einem Einführungswort von F. KLEIN.

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2. Heft: TIMERDING, H. E., Die Mathematik in den physikalischen Lehrbüchern. Mit 22 Figuren. [VI u. 112 S.] 1910. M. 2.80.

3. Heft: ZÜHLKE, P., Der Unterricht im Linearzeichnen und in der darstellenden Geometrie an den deutschen Realanstalten. Mit 14 Figuren. [IV u. 92 S.] 1911. M. 2.60.

4. Heft: HOFFMANN, B., Mathematische Himmelskunde und niedere Geodäsie an den höheren Schulen. Mit 9 Figuren. [VI u. 68 S.] 1912. M. 2.—.

5. Heft: TIMERDING, H. E., Die kaufmännischen Aufgaben im mathematischen Unterricht der höheren Schulen. Mit 5 Figuren im Text. [IV u. 45 S.] 1911. M. 1.60.

6. Heft: GEBHARDT, M., Die Geschichte der Mathematik im mathematischen Unterrichte der höheren Schulen Deutschlands, dargestellt vo allem auf Grund alter und neuer Lehrbücher und der Progammabhand lungen höherer Schulen. [ca 160 S.] 1912.

7. Heft: WERNICKE, A., Mathematik und Philosophische Propädeutik. [VII u. 137 S.] 1912.

8. Heft: LOREY, W., Das Studium der Mathematik an den deutschen Universitäten seit 1870. (In Vorbereitung.)

9. Heft: HÖCKNER, Die Mathematik in der Lebensversicherung. (In Vorbereitung.)

VIERTER BAND—**Die Mathematik an den technischen Schulen.** Mit einem Einführungswort von P. STÄCKEL.

1. Heft: GRÜNBAUM, H., Der mathematische Unterricht an den mittleren technischen Fachschulen der Maschinenindustrie. Mit einem Einführungswort von P. STÄCKEL. [XII u. 99 S.] 1910. M. 2.60.

2. Heft: OTT, Karl, Die angewandte Mathematik an den technischen Mittelschulen der Maschinenindustrie. (Unter der Presse.)

3. Heft: GIRNDT, M., Der mathematische Unterricht an den Baugewerkschulen. (In Vorbereitung.)

4. Heft: SCHILLING, C., und MELDAU, H., Der mathematische Unterricht an den deutschen Navigationsschulen. [VI. u. 82 S.] 1912. M. 2.—.

5. Heft: TROST, Die mathematischen Fächer an den gewerblichen Fortbildungsschulen. (In Vorbereitung.)

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1. *Lenseignement mathématique dans les universités, les écoles techniques supérieures et quelques-unes des écoles militaires,* par C. POSSÉ.—100 p. (3 fr.)
2. *Lenseignement mathématique dans lés écoles de Finlande,* rédigé par une commission instituée par le Sénat impérial de Finlande. 52 p.
3. *Bericht über den mathematischen Unterricht an den russischen Realschulen,* von K. W. VOGT.—16 p. (fr. 0,60)
4. *Lenseignement mathématique dans les écoles primaires et les écoles normales,* par M. S.

Lenseignement mathématique dans les gymnases de garçons du Ministère de l'Instruction publique et dans les *instituts de jeunes filles* du ressort des établissements de l'Impératrice Marie, par M. KONDRATIEV.—29 p. (fr. 1,—)

5. *Lenseignement mathématique dans les Corps des cadets,* par M. POPRUGENKO.

Notice sur les cours pour la préparation des maîtres des Corps de cadets, par M. MAKCHÉEV.—20 p.

6. *a)* Sur l'organisation de l'enseignement mathématique dans les *gymnases de jeunes filles* du ressort du Ministére de l'Instruction publique et à *l'Institut pédagogique de jeunes filles.* Par M. MICHELSON, prof. à cet institut.

b) Sur l'enseignement mathématique dans les *écoles industrielles* du ressort du Ministère de l'Instruction publique. Par MM. KOTOURNITZKY et HATZOUK, professeurs à l'Institut technologique de St-Pétersbourg.

c) Sur l'enseignement des mathématique dans les *gymnases de jeunes filles* dans l'arrondissement scolaire de Varsovie. Par M. GORIATCKEV, prof. à l'Université de Varsovie.—37 p.

Rapports déjà rédigés en langue russe; (en traduction).

a) Les mathématiques dans *l'Institut technologique de St-Pétersbourg.* Par Boris COÏALOVITSCH, prof. à cet institut.

b) Les mathématiques dans les *cours supérieurs de femmes (université de femmes)* à St-Pétersbourg. Par le même.

c) Les mathématiques dans les *cours supérieurs de femmes à Moscou.* Par M. MLODZIEVSKI, anc. prof. à l'Université de Moscou.

d) Les mathématiques dans *l'Institut polytechnique de Varsovie.* Par M. MORDOUKHAÏ-BOLTOWSKAÏ, prof. à l'Université de Varsovie.

e) Sur la préparation des maîtres pour les écoles moyennes secondaires. Par M. KAGAN, prof.-adjoint à l'Université d'Odessa.

f) Les mathématiques dans les *écoles de l'administration générale de l'agriculture.* Par M. N. N.

g) Les mathématiques à *l'Institut de Géodésie* de Moscou, par feu B. STRUVE.

SWEDEN.

DER MATHEMATISCHE UNTERRICHT IN SCHWEDEN, herausgegeben von Dr.

H. von Koch und Dr. E. Göransson.—Editeur: C. E. Fritze, Stockholm, 229 p., 4 fr.

Ecoles primaires et écoles normales, par H. Dahlgren: Die Mathematik an den Volksschulen und Volksschullehrerseminaren Schwedens, 52 p.

Ecoles réales, par E. Göransson et E. Hallgren: Die Mathematik an den schwedischen Realschulen, 28 p.

Gymnases, par E. Göransson: Die Mathematik an den schwedischen Gymnasien, 51 p.

Etablissements de jeunes filles, par O. Josephson et Anna Rönström; Die Mathematik an den höheren Mädchenschulen in Schweden, 23 p.

Ecoles professionnelles élémentaires, par K.-L. Hagström, G. Erickson et C. Heuman: Die Mathematik an elementartechnischen Gewerbeschulen, 22 p.

Ecoles techniques moyennes, par O. Gallander: Der mathematische Unterricht an den technischen Mittelschulen, 8 p.

Ecoles techniques supérieures, par H. von Koch: Die Mathematik an der technischen Hochschule in Stockholm, 13 p.

Universités. par A. Wiman: Die Mathematik an den schwedischen Universitäten, 18 p.

Switzerland.

L'Enseignement mathématique en Suisse. Rapports de la sous-commission suisse publiés sous la direction de H. Fehr.—1 vol., XVI et 756 p. 18 fr., en 8 fascicules en vente séparément, Georg et Cie, Genève et Bâle.

Fasc. 1.—Les travaux préparatoires: Rapport préliminaire sur l'organisation de la Commission et le plan général de ses travaux, publié au nom du Comité central par H. Fehr, secrétaire-général de la Commission (en français et en allemand).

Organisation des travaux en Suisse.—43 p., 1 fr. 50.

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Der mathematische Unterricht an den schweizerischen Primarschulen, von Just. Stöcklin.

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Fasc. 3.—Der mathematische Unterricht an den höheren Mädchenschulen der Schweiz. von E. Gubler, Zürich.

Der mathematische Unterricht an den Lehrer- und Lehrerinnenseminarien der Schweiz, von F. R. Scherrer, Küsnacht.

Organisation und Methodik des mathematischen Unterrichts in den Landerziehungsheimen, von K. Matter, Frauenfeld.—109 p., 2 fr. 25.

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Fasc. 6.—Les mathématiques dans l'enseignement commercial suisse, par L. Morf, Lausanne.—70 p., 2 fr.

Fasc. 7.—Der mathematische Unterricht an der Eidgenössischen Technischen Hochschule, von M. Grossmann, Zürich.—52 p., 2 fr.

Fasc. 8.—L'Enseignement mathématique à l'Ecole d'Ingénieurs de l'Université de Lausanne, par M. Lacombe, Lausanne.

Der mathematische Unterricht an den Schweizerischen Universitäten, von J. H. Graf, Bern.—72 p., 2 fr. 25.

PROBLEM DEPARTMENT.

By E. L. Brown,
Principal North Side High School, Denver, Colo.

Readers of this magazine are invited to send solutions of the problems in which they are interested. Problems and solutions will be duly credited to their authors.. Address all communications to E. L. Brown, 3435 Alcott Street, Denver, Colo.

Algebra.

345. *From Hawke's Advanced Algebra, p. 136, Ex. 35.*

In an A. P. where a is the first term and s is the sum of the first n terms, find the expression for the sum of the first m terms.

Solution by T. M. Blakslee, Ames, Iowa, and Otto J. Ramler, Buffalo, New York.

We have $S_n = \frac{n}{2}[2a+(n-1)d]$,

and $S_m = \frac{m}{2}[2a+(m-1)d]$,

Then $S_n - an = n(n-1)\frac{d}{2}$,

and $S_m - am = m(m-1)\frac{d}{2}$,

Whence $\frac{S_m - am}{S_n - an} = \frac{m(m-1)}{n(n-1)}$,

and $S_m = \frac{m[(m-1)S_n - an(m-n)]}{n(n-1)}$.

346. *Proposed by Norman Anning, North Bend, B. C.*

Express $(a^3+mab+nb^2)(c^3+mcd+nd^2)$ in two ways in the form $X^3+mXY+nY^3$.

I. *Solution by R. M. Mathews, Riverside, Cal.*

The expansion of the first expression is

$a^3c^3+mac(ad+bc)+n(a^2d^2+b^2c^2)+m^2abcd+mnbd(ad+bc)+n^2b^2d^2$. (a)

Assume that X and Y are expressions linear in m and n. Thus

$$X = u_1+mv_1+nt_1, \qquad Y = u_2+mv_2+nt_2. \tag{b}$$

Substituting these in $X^3+mXY+nY^3$, expand, set equal to (a), equate coefficients of terms similar in m and n, and from these equations of conditions solve for the coefficients of u_1, v_1. First, however, the following simplifications are obvious: $t_2 = 0$, because there is no term in n^3 in (a); that $u_1 = \pm ac$, $t_1 = \pm bd$; that as there is no term m^3n then $v_2^2+v_2t_1 = 0$, whence $v_2 = 0$ or $v_2 = -t_1$. $\therefore v_2 = \mp bd$; that as there is no m^3 term, $v_2 = 0$ or $v_1 = 0$, but not both, for then no m^2 term would result to correspond to m^2abcd in (a). Thus we have to consider the following cases:

	X	Y
(1)	$ac+mv_1+nbd$,	u_2.
(2)	$ac+nbd$,	u_2-mbd.
(3)	$ac+mv_1-nbd$,	u_2.
(4)	$ac-nbd$,	u_2+mbd.
(5)	$-ac+mv_1+nbd$,	u_2.
(6)	$-ac+nbd$,	u_2-mbd.
(7)	$-ac+mv_1-nbd$,	u_2.
(8)	$-ac-nbd$,	u_2+mbd.

When the work is carried through it develops that (2), (3), (5) and (8) impose incompatible conditions on the undetermined coefficients of v_1 and

u_2; on the other hand we obtain two solutions apiece from (1) and (7), and one each from (4) and (6). Those from (7) and (6) are the negatives of those from (1) and (4), respectively. They are

$$\begin{aligned} X &= \pm(ac+mbc+nbd), & Y &= \pm(ad-bc). \\ &= \pm(ac+mad+nbd), & &= \pm(bc-ad). \\ &= \pm(ac-nbd), & &= \pm(ad+bc+mbd). \end{aligned}$$

As a result we have the given product expressed in the required form in *three* independent ways.

II. *Solution by E. B. Escott, Ann Arbor, Mich.*

$$a^2+mab+nb^2 = \left(a+\frac{mb}{2}\right)^2-\left(\frac{m^2}{4}-n\right)b^2$$
$$= A^2-Db^2,$$

Where $A = a+\frac{mb}{2}$, $D = \frac{m^2}{4}-n$.

Also $c^2+mcd+nd^2 = C^2-Dd^2$, where $C = c+\frac{md}{2}$.

The following method is given in Euler's Algebra:

$$A^2-Db^2 = (A+b\vee D)(a-b\vee D).$$

$$\therefore \quad (A^2-Db^2)(C^2-Dd^2) = (A+b\vee D)(A-b\vee D)(C+d\vee D)\cdot$$
$$\cdot(C-d\vee D).$$

Combine first and third factors, also second and fourth.

Above product $= [AC+bdD+(Ad+Cb)\vee D]\cdot$
$\cdot[AC+bdD-(Ad+Cb)\vee D]$
$= AC+bdD)^2-D(Ad+Cb)^2.$

Since $X^2+mXY+nY^2 = \left(X+\frac{m}{2}Y\right)^2-DY^2$,

we have $X+\frac{m}{2}Y = AC+bdD$

and $Y = Ad+Cb.$

Whence $\begin{cases} X = ac-nbd. \\ Y = ad+bc+mbd. \end{cases}$

A second set of values is obtained by combining the factors in another way; *i. e.*, by taking the product of first and fourth factors, also second and third.

We get $(A^2-Db^2)(C^2-Dd^2) = (AC-bdD)^2-D(Ad-Cb)^2$;
or this could have been obtained by changing the sign of d in preceding formula.

$$X+\frac{m}{2}Y = AC-bdD.$$
$$= ac+\frac{m}{2}(bc+ad)+nbd.$$
$$Y = Ad-Cb = ad-bc.$$

From which we get

$$\begin{cases} X = ac+mbc+nbd. \\ Y = ad-bc. \end{cases}$$

Geometry.

347. *Proposed by H. E. Trefethen, Waterville, Maine.*

O is a point in a given triangle ABC; x, y, z are the perpendiculars from O on the sides a, b, c respectively. When $x : y : z = a : b : c$,

(1) Find x, y, z in terms of the sides;

(2) Prove that the lines AO, BO, CO (produced) divide each the

opposite side into segments proportional to the squares of the adjacent sides;

(3) Prove that $x^2+y^2+z^2 =$ minimum.

Solution by Nelson L. Roray, Metuchen, N. J.

(1) The point O is the symmedian point of the triangle ABC.

Suppose $x = ma, \quad y = mb, \quad z = mc.$

Then $\Delta BOC = \frac{1}{2}ax = \frac{1}{2}ma^2, \quad \Delta COA = \frac{1}{2}mb^2, \quad \Delta AOB = \frac{1}{2}mc^2.$

Hence, $ma^2+mb^2+mc^2 = 2K$, where K = area of ΔABC.

Then $m = \dfrac{2K}{a^2+b^2+c^2}$ and $x = \dfrac{2aK}{a^2+b^2+c^2}, \; y = \dfrac{2bK}{a^2+b^2+c^2}, \; z = \dfrac{2cK}{a^2+b^2+c^2}.$

(2) Produce CO to intersect AB in R.

$\Delta BOC : \Delta AOC = ax : by = a^2 : b^2.$

$\Delta BOR : \Delta ORA = BR : RA.$

$\Delta BOR : \Delta BOC = RO : OC.$

$\Delta AOR : \Delta AOC = RO : OC.$

$\therefore \; \Delta BOC : \Delta AOC = \Delta BOR : \Delta ORA.$

$\therefore \; a^2 : b^2 = BR : RA.$

Similarly for the other ratios.

(3) Let O′ be any other point within the triangle and x', y', z' the perpendiculars from O′ to a, b, c, respectively.

Then $x' : y' : z' = ma : nb : pc.$

Whence $x' = \dfrac{2nbK}{ma^2+nb^2+pc^2}, \; y' = \dfrac{2nbK}{ma^2+nb^2+pc^2}, \; z' = \dfrac{2pcK}{ma^2+nb^2+pc^2}.$

$$\therefore \; (x'^2+y'^2+z'^2)-(x^2+y^2+z^2) = \frac{a^2b^2(m-n)^2+a^2c^2(p-m)^2+b^2c^2(p-n)^2}{(ma^2+nb^2+pc^2)^2(a^2+b^2+c^2)},$$

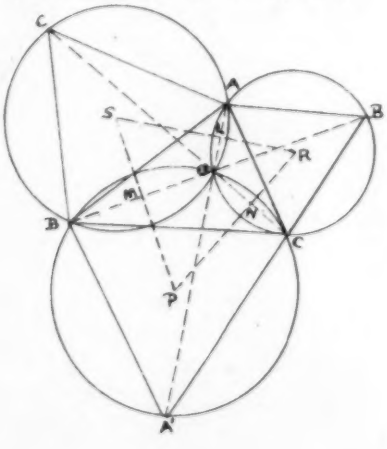
a positive number.

$\therefore \; x^2+y^2+z^2$ is a minimum.

348. *Proposed by A. G. Browne, Cedar Rapids, Iowa.*

If equilateral triangles be described (outward) on the sides of any triangle: (1) the lines joining the vertices of the original triangle to the opposite vertices of the equilateral triangles are concurrent; (2) the circles described about the equilateral triangles are concurrent; (3) the centers of these circum-circles form another equilateral triangle.

I. *Solution by A. M. Harding, Fayetteville, Ark.*



(1) Let BB′ and CC′ intersect in O. Join AO and OA′. It is required to prove that AO, OA′ are in the same straight line. Since AB = AC′, and AC = AB′, and the $\angle BAB' = \angle CAC'$, the triangle CAC′ and BAB′ are congruent. Therefore, $\angle ABO = \angle AC'O$, and $\angle ACO = \angle AB'O$. Hence the quadrilaterals C′AOB and B′AOC are inscriptible. The $\angle AOB = \angle AOC = 120°$. $\therefore \angle BOC = 120°$. Since $\angle BA'C = 60°$, the quadrilateral BOAC′ is inscriptible. Hence $\angle BOA' = 60°$. Since $\angle AOB + \angle BOA' = 180°$, AO and OA′ are in the same straight line.

(2) Since the quadrilaterals C′AOB, B′AOC, A′BOC are inscriptible, the three circles are concurrent.

(3) Since the angles at L, M, N are right angles and $\angle LON = \angle NOM = \angle MOL = 120°$, $\angle P = \angle R = \angle S = 60°$. $\therefore$ Triangle PRS is equilateral.

II. *Solution by Elmer Schuyler, Brooklyn, N. Y.*

Construct circles P, R, S, such that the chords AB, BC, CA divide circles into arcs of 120° and 240° the minor arcs passing through the triangle. Let circles R, S intersect in O. Then $\angle AOB = AOC = 120°$. Hence $\angle BOC = 120°$ and circle P will pass through O also. Produce BO to meet circle R in B′. Since $\angle BOC = 120°$; $\therefore \angle B'OC = \angle B'AC = 60°$. Also since $\angle AOC = 120°$, $\therefore \angle AB'C = 60°$. Hence $\Delta AB'C$ is equilateral. Produce CO to C′ and AO to A′. Likewise we can prove triangles ABC′ and BCA′ equilateral. Obviously angles P, R, S are supplementary to angles BOC, AOC, AOB. Hence P = R = S = 60° and the ΔPRS is equilateral.

349. *Selected.*

If upon the base BC of a triangle two equilateral triangles BCE, BCE′ be described on opposite sides, and their vertices E, E′ be joined to A, then (1) if Δ denote the area of ABC, $AE^2 - AE'^2 = 4\Delta\sqrt{3}$; (2) $AE^2 + AE'^2 = AB^2 + BC^2 + CA^2$.

I. *Solution by M. G. Schucker, Pittsburg, Pa., and G. I. Hopkins, Manchester, N. H.*

(1) Let A and E′ be on same side of BC. Join EE′, intersecting BC in O. Join AO, and draw AM, AN $\perp$ to BC, EE′. Now $AE^2 - AE'^2 = EN^2 - E'N^2 = 4EO \cdot ON = 4\sqrt{3}OC \cdot ON$; but $OC \cdot ON$ = area of triangle ABC. $\therefore AE^2 - AE'^2 = 4\sqrt{3}\Delta$.

(2) $AE^2 + AE'^2 = 2AO^2 + 2OE^2 = 2AO^2 + 6OC^2$. Again, $AB^2 + AC^2 = 2AO^2 + 2OC^2$, and $BC^2 = 4OC^2$. $\therefore AB^2 + BC^2 + CA^2 = 2AO^2 + 6OC^2$.

Hence $AE^2 + AE'^2 = AB^2 + BC^2 + CA^2$.

II. *Solution by R. M. Mathews, Riverside, California.*

We have $\overline{AE}^2 = \overline{AB}^2 + \overline{BE}^2 - 2AB \cdot BE \cos(60° + B)$.

$= \overline{AB}^2 + \overline{BC}^2 - 2AB \cdot BC \cos(60° + B)$.

and $\overline{AE'}^2 = \overline{AB}^2 + \overline{BC}^2 - 2AB \cdot BC \cos(60° - B)$.

Whence $\overline{AE}^2 - \overline{AE'}^2 = 2AB \cdot BC[\cos(60 - B) - \cos(60 + B)]$.

$= 4AB \cdot BC \sin 60° \sin B$.

$= 4 \cdot \frac{1}{2}AB \cdot BC \sin B \cdot \sqrt{3} = 4\Delta\sqrt{3}$.

Also $\overline{AE}^2 + \overline{AE'}^2 = 2\overline{AB}^2 + 2\overline{BC}^2 - 2AB \cdot BC[\cos(60° + B) + \cos(60 - B)]$.

$= 2\overline{AB}^2 + 2BC^2 - 4AB \cdot BC \cos 60° \cos B$.

$= 2\overline{AB}^2 + 2BC^2 - 2AB \cdot BC \cos B$.

$= \overline{AB}^2 + BC^2 + (AB^2 + BC^2 - 2AB \cdot BC \cos B)$.

$= \overline{AB}^2 + BC^2 + CA^2$.

CREDIT FOR SOLUTIONS.

345. T. M. Blakslee, I. E. Campbell, Walter C. Eells, A. M. Harding.

R. M. Mathews, A. L. McCarty, Harriet L. Pope, Otto J. Ramler, Nelson L. Roray. M. G. Schucker, Elmer Schuyler, George L. Sosnow. (12)

346. E. B. Escott, A. M. Harding, R. M. Mathews. (3)

347. A. M. Harding, Nelson L. Roray. (2)

348. A. M. Harding, Nelson L. Roray, M. G. Schucker, Elmer Schuyler. (4)

349. T. M. Blakslee, Annie M. Fracker, A. M. Harding, G. I. Hopkins, R. M. Mathews (2 solutions), Harriet L. Pope, Nelson L. Roray, M. G. Schucker, Elmer Schuyler. (10)

Total number of solutions, 31.

PROBLEMS FOR SOLUTION.

Algebra.

361. *Proposed by Norman Anning, Chilliwack, B. C.*

Show, without dividing, that $x^4-x^3+x^2-x+1$ is a factor of $x^{44}-x^{33}+x^{22}-x^{11}+1$.

362. *Proposed by Orville Price, Denver, Colo.*

If $$\frac{b^2+c^2-a^2}{2bc}+\frac{c^2+a^2-b^2}{2ca}+\frac{a^2+b^2-c^2}{2ab}=1,$$

show that each of two of the three fractions must be equal to 1, and the other to —1.

Geometry.

363. *Proposed by W. T. Harlow, Portland, Oregon.*

From the middle point of one of the edges of a regular tetrahedron a fly descends by crawling around the tetrahedron, and reaches the base at the point where the edge meets the base. Find at what point the fly must cross the other edges if its path is everywhere equally inclined to the plane of the base. (Phillips & Fisher's Geometry, Problem No. 175, Page 482.)

364. *Proposed by S. F. Parson, DeKalb, Ill.*

A mile race track has two intersecting "straight-ways" each 1000 feet in length and tangent to the circular arc which completes the mile. Required the radius of the arc.

365. *Proposed by H. E. Trefethen, Waterville, Maine.*

If d is the distance between the mid-points of the circular arc s and its chord c, the error in taking $c = s-8d^2/3s$ is less than $32d^4/3s^3$. Derive these formulas and prove the statement.

1913 MEETING OF THE ASSOCIATION OF COLLEGES AND SECONDARY SCHOOLS IN THE SOUTHERN STATES.

The 1913 meeting of the Association of Colleges and Secondary Schools of the Southern States will take place on November 6th, 7th and 8th, at the University of Tennessee, Knoxville, Tennessee. The principal subject of discussion will be the accrediting system which is now being put into operation by the Association in the Southern States.

A copy of the complete programme will be sent you later.

J. L. HENDERSON, University of Texas, President.
BERT H. YOUNG, Vanderbilt University, Sec'y and Treas.

CHEMISTRY SECTION ANNOUNCEMENT.

The committee appointed by the Chemistry Section of the Central Association of Science and Mathematics Teachers at the annual meeting in November, 1912, announces a change of plan in carrying on its work.

Some months ago a circular letter was mailed to all chemistry teachers of the Association, as well as many others in the middle states. This letter presented some experiments and urged co-operation with the committee in carrying out the purpose of the Chemistry Section. This purpose was "to collect and publish experiments, suitable for use, that were not in the present laboratory manuals." The number of responses up to this time has been disappointing. The committee is not discouraged, however. It is sure that it has the *silent* sympathy of many capable teachers.

It wishes to acknowledge the friendly interest and proffers of assistance of at least thirteen teachers who have replied to the letter; and especially the receipt of experiments from five others as follows:

Dr. Nicholas Knight, Cornell College, Iowa.
Prof. E. P. Schoch, University of Texas, Austin.
Mr. C. W. Botkin, Ottumwa H. S., Iowa.
Mr. V. G. Heller, Marinette H. S., Wis.
Miss Alice Child, E. Div. H. S., Milwaukee, Wis.

While much of the material is not original, yet the committee is pleased to receive it as an indication of interest and of illustration of what is being done elsewhere. If it is not already used, all may be sure that it will be used somewhere. While the primary aim was to collect new unpublished experiments the committee recognizes that many published experiments have not come to the notice of some teachers, as yet. For this reason some experiments will be old to the more experienced and energetic teachers, while quite new to those of less experience in teaching. The committee expects, later on, to work toward the preparation of a list of standard experiments, from which teachers may select those which best suit their local needs.

The few responses to the circular letter does not justify the further expense of this means of spreading the committee's reports, but the courtesy of the publishers of SCHOOL SCIENCE AND MATHEMATICS makes it possible for the committee to use the monthly issues of this periodical. The further reports of the committee may be found in it. The attention of all chemistry teachers is called to the experiments given in this issue. Please devise or search out others that have the following general characteristics which make them valuable in proportion to the content of these qualities: Universality of interest, not difficult of execution by students, not long and tedious in operation, and the cost of materials within moderate bounds.

The committee again urges all chemistry teachers to assist in all possible ways to keep a vital interest in the study of chemistry; and not let the teaching of it grow into mere formalism.

H. R. SMITH, Highland Park, Ill.
A. C. NORRIS, Rockford, Ill.
C. M. WIRICK, Crane H. S. Chicago.
Committee.

DETERMINING THE FINENESS OF GOLD.

All students possess gold jewelry of some sort or another and frequently want to know its fineness. The chemistry teacher is often asked to test the gold of the class pins or rings. It seems that an easy, quick method of doing this accurately would be apppreciated by teachers and students, so the following one is offered:

The following acids will not noticeably affect the gold alloys for which each one is prepared, but will leave a brown spot on alloys having a lower grade of fineness.

For *22K. gold.*
30 c.c.m. of c. p. HNO_3.
4 drops of c. p. HCl.

For *20K. gold.*
30 c.c.m. of c. p. HNO_3.
3 drops of c. p. HCl.

For *18K. gold.*
60 c.c.m. of c. p. HNO_3.
2 drops of c. p. HCl.

For *14K. gold.*
Use c. p. HNO_3.

It is not always easy for one without experience to decide accurately from the results of these tests. A little practice with alloys of known fineness will enable even a student to be reasonably certain of the grade of the gold.

For small expense one can purchase a jeweler's gold-testing stone, and a set of standard gold alloy needles. With these the amateur can test any gold ornament without injurying it, and can do it accurately in a few minutes time. The procedure is as follows:

Some part of the gold article is rubbed on the stone. A gold streak, quite noticeable on the black stone, is left. Then several needles are selected whose fineness is nearest that of the article. One usually has some idea of what the fineness is, or is said to be. Streaks close to the first one are made on the stone with the needles, then with a glass rod some aqua regia from the 22K. mixture above, a streak of acid is made across all the streaks of gold. The lowest grade alloy will be acted on first and most rapidly. The action on whichever standard alloy that corresponds most closely to the action on the gold of the article indicates plainly what the fineness is. If the action is entirely different from that on the standard alloys other needles are selected for use as before. In case of possible doubt it is better to err by calling the fineness too low rather than too high. Gold *plated* articles are known by the test of high fineness, but low cost. Aqua regia of greater strength can be used if desired.

This test with needles and stone is practically the only one used in the trade, and its reliability is unquestioned by jewelers. Every school teaching chemistry should have a stone and needles, and should use it instead of the usual experiment of testing effect of acids on gold leaf; or use it in conjunction with that experiment. The stone and needles may be obtained by post from Swartchild and Co., Heyworth Bldg., Chicago. The thirty-five cent stone is large enough. Ask for "a good black Scotch pebble gold-testing stone." The needles differ in fineness by two carats and range from 4-20K. First grade quality are two dollars, second grade are a dollar and seventy-five cents; and are as accurate as first grade. They are not finished quite so well.

H. R. SMITH.

THE ANALYSIS OF GOLD ORE.

The Assay Ton (A. T.) is 30 grams, and the milligrams of gold in 30 grams of ore represent the ounces in a ton of 2,000 lbs.

Take 10 grams (⅓ A. T.) of the fine powder in a porcelain evaporating dish. Treat, on the water bath, with aqua regia, the dish being covered with a watch glass. This dissolves the gold as follows:

$$HCl+HNO_3 \rightarrow Cl+H_2O+NO_2$$
$$Au+3Cl \rightarrow Au\,Cl_3$$

The nascent chlorine from aqua regia dissolves the gold.

Filter, and evaporate the filtrate to dryness on water bath, and add successive portions of water until there is no further odor of acid. Then add water, and precipitate the gold with green crystals of ferrous sulphate, and leave for several hours on the warm water bath. The gold is precipitated as a purple powder as follows: $3FeSO_4+AuCl_3 \rightarrow Fe_2(SO_4)_3+FeCl_3+Au$. Filter off the gold, dry the precipitate, and determine in the usual way—the result in milligrams multiplied by three gives the ounces per ton of the ore.

The original 10 grams of ore may be weighed on quite an ordinary balance, but the gold should be weighed, if possible, on a fine analytical balance. The process described is called a chemical assay to distinguish it from a fire assay. NICHOLAS KNIGHT.

HAMPTON INSTITUTE WORK FOR NEGROES.

Hampton Institute's remarkable results in training negroes are vividly set forth in the forty-fifth annual report of the principal, just made public. From a school of fifteen pupils and two teachers the Institute has grown into a busy educational village of over a thousand persons, with a far-reaching influence, not only for the races it is designed to aid, but for the whole nation, which benefits by the splendid work and example of Hampton graduates everywhere.

Industrial training is the keynote of the Hampton success, according to Dr. P. P. Claxton, United States Commissioner of Education, who is keenly interested in the Hampton work. It is noteworthy that this industrial training is of the most immediate and practical sort, applied to the ordinary producing tasks of life, first of all in the educational plant itself. At Hampton practically all the work is done by the students themselves. There are buildings to be kept in repair and occasional new buildings to be erected; there is a farm of 600 acres to be cultivated, with 150 cows and young stock, 40 horses and mules, hogs and poultry. There are horses to be shod, harness to be kept in repair, wagons to be built, boys to be clothed—these are a few of the industrial opportunities which the plant itself offeds. Last year the students received over $86,000 in wages, of which about one-fourth went to the girls for domestic work in the Institute.

This year the boys of the trade school have built Clarke Hall at a contract price of $26,142. The work called for the services of bricklayers, plasterers, carpenters, sheet metal workers, steam fitters, plumbers, cabinet makers, electricians, and painters. The architect who designed the building, after inspecting the brickwork done by the boys, said it compared favorably with similar work by New York men; and some of the local builders pronounced it the best piece of work in that section of Virginia.

At Hampton work is considered a privilege; in fact, one form of punishment is the taking away of work from a pupil. No student is ever punished by being forced to work. At the same time, labor is not insisted on as an end itself, but rather as the means to an end. "The aim of Hampton," says Dr. George P. Phenix, vice-principal, "is not merely to train workmen, but to educate men and women who shall stand for the best things in the communities to which they return, and who can make their skill contribute to this end."

ANNUAL MEETING OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

The next annual meeting of the Central Association of Science and Mathematics Teachers will be held at Des Moines, Iowa November 28th and 29th.

Plans for the meeting are now perfected. And what will prove to be one of the best programs in the history of the Association has been arranged. It is practical. It deals with some of the foremost problems relating to the teaching of science and mathematics of the present time, and among the speakers are many of the ablest and most prominent teachers of the county.

The vocational aspects of education as related to the teaching of the various sciences and mathematics in the secondary schools especially and in the colleges are to be the objects of a large portion of the discussions at the general sessions and in the meetings of the five sections of the Association.

Dr. Florian Cajori, Colorado College, Colorado, known throughout the scientific world for his writings on the history of mathematics, the history of science, etc., will give an address at the general session November 28th, on "Science and Mathematics in Vocational Schools; a Retrospect." At the same session Dr. Otis W. Caldwell, Dean of University College, University of Chicago, will give an address on "Science and the Changing Ideals of Education."

The following programs of the Mathematics Section will give an idea of the character of the programs of all the sections.

FRIDAY, NOVEMBER 28TH, 1:30 P. M.

Report of Committee on Vocational Mathematics—R. L. Short, West Technical High School, Cleveland, Ohio.

Discussion of the Report from the Points of View of:

1. The College and College Preparation—W. A. Smith, University of Iowa.
2. The General High School—W. Lee Jordan, High School, Des Moines, Iowa.
3. The Industrial or Technical School—W. G. Swartz, Director of Industrial Mathematics, Gary, Ind.

Five-minute Reports from Various Schools Where Work has been Done along the Lines of Vocational Mathematics:

1. H. L. Terry, State High School Inspector, Madison, Wis.
2. Perry D. Smith, Francis W. Parker School, Chicago.
3. A. W. Cavanaugh, Lewis Institute, Chicago.
4. Miss M. A. Lynch, McKinley High School, St. Louis, Mo.

General Discussion and Action on the Report.

SATURDAY, NOVEMBER 29TH, 10 A. M.

Report of Committee on Examinations and Results—C. E. Comstock, Bradley Polytechnic Institute, Peoria, Ill.

The Traditional Examination in Mathematics—Miss Jane V. Pollock, New Trier High School, Kenilworth, Ill.

Means of Measuring Mathematical Abilities—Dr. Florian Cajori, Colorado College, Colo.

General Discussion and Action on the Report.

There are five sections of the Association: The Mathematics Section, Biology Section, Chemistry Section, Earth Science Section, and Physics Section. Each has a program similar to the above.

Dr. Rollin D. Salisbury, Professor of Geography, University of Chicago.

will give a popular illustrated address the evening of November 28th, on "In and About Patagonia." Dr. Salisbury, who is one of the greatest geographers of the world, spent a great part of last year in this South American country.

Every teacher of science or mathematics who can arrange to go to Des Moines at the Thanksgiving recess should make plans now to attend the meeting.

PACIFIC COAST ASSOCIATION OF PHYSICS AND CHEMISTRY TEACHERS.

The Pacific Coast Association of Chemistry and Physics Teachers met in the Chemistry Building of the University of California at Berkeley on July 10th, for the first meeting of its annual session in connection with the University Summer session.

Professor G. N. Lewis, Dean of the College of Chemistry of the University of California, spoke on "The Content and Method of the High School Course in Chemistry" The University Faculty Committee, he stated, had decided that the same elementary course in chemistry should be given to all students, irrespective of what future course or life-work they were to pursue. Professor Lewis emphasized the need of local illustrations in presenting chemical phenomena.

Pursuing the same line of thought, Professor E. P. Schoch, Professor of Physical Chemistry, University of Texas, gave an interesting and instructive talk, also emphasizing the need of localizing the subject of chemistry, as well as applying the textbook principles to everyday chemical substances, thereby helping to vitalize the science.

On the following afternoon, the following officers were elected for the ensuing year:

President, B. A. Perkins, Berkeley, Cal.
Vice-President, W. H. Weslar, Berkeley, Cal.
Secretary-Treasurer, C. P. Finger, 550 25th St., Oakland, Cal.

Following the election of officers, Professor R. S. Minor of the Physics Department of the University of California, delivered an interesting sermon and experimentally demonstrated that a siphon will operate in a vacuum and will cause water to flow upward through an arm greater than the barometric height.

Informal discussion of various phases of Science teaching followed and this ended the best attended and very successful meeting of the Association.

AN EXPERIMENT IN CONDUCTING ADVANCED PHYSICS WORK IN THE HIGH SCHOOL.

By C. M. Hall,
Central High School, Springfield, Mass.

With the advanced class in Physics recently, we have tried a method giving such satisfactory results that it is here described for the benefit of others who may wish to use it.

The class was composed of six boys and one girl, seniors and post graduates, all having had one year of college preparatory Physics.

The first few weeks were occupied in reviewing laboratory experiments and in problem work. Then the class was informed one day that they

were to be called the "Central Research Company," with office and laboratory in the Central High School, the instructor being "chief engineer." They were to be "consulting engineers" and would be called upon to solve certain problems, make experimental tests and prepare reports on various topics, which would be presented to them in the form of business letters requiring clear, definite answers.

These "letters" contained requests for investigations upon various topics throughout the range of Physics, but only a few samples can be quoted:

Central Research Company,
Consulting Engineers,
Room 36, C. H. S.

Gentlemen: If we make the lever of the accompanying safety valve of the same cross section it is at the center of its length and wish to set the ball for 300 lbs./sq. in., where shall the ball be placed? Please test the 60 lbs. mark under water pressure and advise us if it is in error.

Yours truly,
ARNOLD BROS.,
Boiler Makers.

Other letters were:

Kindly furnish us the weight of a casting in the form of a sphere 4 feet in diameter made of the sample material. We wish to know the pounds and the kilograms weight.

Please graduate the accompanying glass vessel for us in cubic centimeters.

Please compare the accompanying brass weight with water and advise us of its error.

Please test the accompanying graduate at five well spaced points along the scale and let us know the errors.

The model of hydraulic ram we are sending you fails to work in our hands. Please set same up, operate and advise us of the proper operating conditions.

Kindly test the block and tackle sent you at five loads up to maximum and let us know its efficiency at each load.

We are informed that the capillary rise of water in a glass tube is dependent in some degree upon the temperature of the water. Kindly test the accompanying tube with water at various temperatures and advise us. We wish to use the device as a new kind of thermometer requiring neither vacuum nor sealing. Let us know your opinion of the practicability of our device.

These "letters" were handed out by the chief engineer as fast as the associates worked themselves out of a job. Interest was immediate.

The engineers had the run of the laboratory, the chief merely advising, helping to find apparatus and criticizing the form and contents of the reports filed.

As far as possible the associates must look up their own methods of attacking the problem and arrangement of apparatus. They were required to show the chief an outline of their proposed solution of the problem for approval before starting.

On approval, the associate proceeded to collect the necessary apparatus and was allowed a week, if necessary, to complete the experimental work.

The tests completed, an outline report is submitted to the chief for inspection and correction.

The chief suggests corrections, sources of error, better methods or

further tests and the associate then prepares a final report in answer to his letter.

One sample of such a report follows:

Arnold Brothers,
Boiler Makers.

Gentlemen: Replying to your request for information on lever safety valve sent us, we wish to state that for 300 lbs./sq. in. you should set the ball at 20.5 in. from the fulcrum.

We find on water pressure that the valve lifts at 59.0 lbs. gage, when the ball sets at the 60 lbs. mark.

Yours truly,
CENTRAL RESEARCH COMPANY.
per (pupil),

One boy who had to determine the accuracy of a brass weight by comparison with water, even looked up a table of densities of water at various temperatures, to see if the error caused by using water at the laboratory temperature instead of 4 degrees C., could cause an appreciable error in his work.

The result of the above outlined method of handling the advanced work has been an increase of interest in Physics principles, a development of reasoning power and some knowledge of the application of Physics principles in solving practical problems.

ARTICLES IN CURRENT PERIODICALS.

American Botanist for August; *209 Whitley Ave., Joliet, Ill.; $1.00 per year, 25 cents a copy:* "The Surprise Lily," S. I. Anthon; "Pentstemon Grandiflorus," H. Tullsen; "The Day Lilies," Willard N. Clute; "Plants of the South Dakota Sand Hills," S. S. Visher; "The Moonwort," Adella Prescott.

American Forestry for September; *1410 H. Street N. W., Washington, D. C.; $2.00 per year, 20 cents a copy:* "Some Methods of Securing Closer Utilization" (2 illustrations), R. C. Bryant; "Grazing Administration of the National Forests in Arizona" (8 illustrations), R. R. Hill; "Forestry at the National Conservation Congress" (4 illustrations); "The Recent Connecticut Law for the Taxation of Forest Lands" (4 illustrations), Herman H. Chapman; "A Record of Forest Work in Hawaii" (11 illustrations); "Management of White Pine Forests" (6 illustrations), A. F. Hawes; "The White Mountain Forest and How It Is to Be Made Useful," Wm. L. Hall.

American Naturalist for August; *Garrison, N. Y.; $4.00 per year, 50 cents a copy:* "Genetical Studies on Oenothera. IV," Bradley M. Davis; "The Influence of Protracted and Intermittent Fasting Upon Growth," Sergius Morgulis; "Cambrian Holothurians," Austin H. Clark; Shorter Articles and Discussion: "Viability and Coupling in Drosophila," P. W. Whiting; "The Results Obtained by Crossing Zea mais L. and Euchlaena mexicana Schrad," Mary G. Lacy.

American Mathematical Monthly for September; *Benjamin F. Finkel, Springfield, Mo.; $2.00 per year, 25 cents a copy:* "History of the Exponential and Logarithmic Concepts," Florian Cajori; "The Significance of the Weierstrass Theorem," E. R. Hedrick; "On the Impossibility of Certain Diophantine Equations and Systems of Equations," R. D. Carmichael; "Problems and Questions," B. F. Finkel, Chairman.

Catholic Educational Review for September; *Washington, D. C.; $3.00 per year, 35 cents a copy:* "The Teaching Office of the Catholic Church," Thomas J. Shahan; "The Teaching of Philosophy in the College," Edward A. Pace.

Education for September; *120 Boylston Street, Boston; $3.00 per year, 35 cents a copy:* "A Review of the Pedagogical Studies in the Teaching of Spelling," Mary A. Grupe; "Teaching Practical Politics in our Schools," J. Madison Gathany; "The Responsibility of the Schoolroom," Helen L. Abbott; "Public Speaking and Dramatics in High Schools," J. Milnor Dorey; "What Does it Cost to Build a College?" Wallace N. Stearns.

Journal of Geography for September; *Madison, Wisconsin; $1.00 per year, 15 cents a copy:* "The Waterways of Germany," Charles E. Spencer; "The Establishing of the Ohio-Michigan Boundary Line," Constance G. Eirich; "Petroleum," C. L. Drake; "The Multiplication Tables of Geography," W. A. Owens; "How Old Is the Earth?"; "What Is a Standard School Geography?"

L'Enseignement Mathématique for July; *Stechert & Co., West 25th St., New York; 15 francs per year, 3 francs per copy:* "Sur l'existence des potentiels et de leurs dérivées," C. Jaccottet; "L'edifice géometrique et la démonstration," P. Boutroux; "Sur le prolongement, par continuité, des fonctions d'une variable complexe," D. Pompéiu; "Sur la résolution graphique d'un système de trois équations linéaires." M. d'Ocagne; "Démonstration nouvelle et extension d'un théorème de M. G. Koenigs," L. Godeaux; "Sur les ronlettes à base rectiligne," E. Turrière; "Sur les axes principaux d'inertie," F. Bouny.

Mathematical Gazette, for July; G. Bell & Sons, Portugal St., Kingsway, London; six no., 9 s. per year, 1 s. 6 d. per copy: "A General Mathematical Syllabus for Non-specialists," Report by the Public Schools Special Committee; "The Early History of the Mathematical Gazette," E. M. Langley; "Notes on the Parallel-Axiom," W. B. Frankland; "The Teaching of Geometry and Trigonometry," W. J. Dobbs; "Notes on the Radix Method of Calculating Logarithms," Sidney Lupton; "Mathematical Notes," J. I. Craig, and others.

National Geographic Magazine for September; *Washington, D. C.; $2.50 per year, 25 cents a copy:* "The Resurrection of Ancient Egypt" (46 illustrations and map), James Baikie; "Reconstructing Egypt's History" (21 illustrations), Wallace N. Stearns; "The Sacred Ibis Cemetery and Jackal Catacombs at Abydos" (7 illustrations), Camden M. Cobern.

Nature Study Review for September; *Ithaca, N. Y.; $1.00 per year, 15 cents a copy:* "A Lesson on Squirrels—Chipmunks," Anna B. Comstock; "Children's Interests in Nature Materials," Gilbert H. Trafton; "A Wild Flower Garden," Norma E. Nelson; "A Course in the Natural History of the Farm," J. G. Needham; "Simple Experiments in Animal Behavior," W. C. Allee; "Criticism of School Garden."

Photo-Era for September; *383 Boylston St., Boston; $1.50 per year, 15 cents a copy:* "The Work of Dr. D. J. Ruzicka," Phil M. Riley; "Commercial Photography on the Plains," J. Clarence Norton; "The Status of the Amateur," Claude Davis Millar; "Converting an Anastigmat into a Soft-Focus Lens," John W. Gillies; "The Bromide-Gum Process," William S. Davis; "Pencil-Colored Oil-Transfers," Robert Demachy.

Physical Review for August; *Ithaca, N. Y.; $6.00 per year, 50 cents a copy:* "A Porous Plug Method for the Mechanical Equivalent of Heat," J. R. Roebuck; "A Study of Some Changes in the Air-Liquid Contact Potential Difference," G. W. Moffitt; "On the Elementary Electrical Charge and the Avogadro Constant," R. A. Millikan; "The Emissivity of Oxidized Metallic Surfaces," C. P. Randolph and M. J. Overholser; "The Action of Mercury Vapor on Selenium," F. C. Brown.

..Popular Astronomy for August-September; *Northfield, Minn.; $3.00 per year, 15 cents a copy:* "Laboratory Tests of Photographic Plates and Filters for Astronomical Work," Harold L. Alden; "The Answer of the Universe," George Howard Gibson; "Sunspots and the Planets," George F. Kronenberger; "The North Pole," William F. Rigge; "Considerations on the Physical Appearance of the Planet Mars," E. M. Antoniadi.

Popular Science Monthly for October; *Garrison, N. Y.; $3.00 per year, 30 cents a copy:* "Immigration and the Public Health," Alfred C. Reed; "An Irish Channel Railway," Henry Tyrell; "Scientific Standards for the Governmental Regulation of Foods," John R. Murlin; "A Problem in

Educational Eugenics," Chas. W. Hargitt; "The Psychological Factor in Southern Race Problems," James Bardin; "Women in Industry," D. R. Malcolm Keir; "The Fourth Dimension," Samuel M. Barton; "Some Psychological Problems emphasized by Pragmatism," Josiah Royce.

School Review for September; *University of Chicago Press; $1.50 per year, 20 cents a copy:* "Economy in Education," Harry Pratt Judson; "Qualifications, Salary, and Tenure of the Teachers in the Commissioned High Schools of Indiana," Samuel E. Shideler; "The Use of Scientific Material in the High-School Course in English," H. O. Church; "College Entrance and Advanced Credits for Manual Arts," F. D. Crawshaw; "The Institutional High School and What It Does for the Community," R. L. Short.

School World for September; *Macmillian and Company, London, Eng.; 7 s. 6 d. per year, 6 pence a copy:* "The Kinematograph in the Teaching of Natural Science," H. O. Hale; "The Correction and Supervision of Written Work in Girls' Secondary Schools," Miss M. E. Wigg; "Parent-Teacher Associations," Miss Hilda Wilson; "A School Wireless Installation," H. Matthews; "Shorthand and Typewriting in Secondary Schools," Fred Charles, B. A.; "The State and the School," J. S. Thronton; "The Secondary Education of Girls in Prusssia. II," Mark P. Mayo; "The Kinematograph in Education"; "Secondary Education in England in 1911-12."

Unterrichtsblätter für Mathematik und Naturwissenschaften, Nr. 5; *Otto Salle, Berlin, W. 57, Germany; 4 M. per year, 60 pf. per copy:* "Ueber Fortbildungssemester für Lehrer an höheren Schulen," Prof. Dr. Hess; "Ueber den physikalischen und chemischen Unterricht an den bayerischen Real und Oberrealschulen," Dr. End; "Neuere Erkenntnisse der Meteorologie und ihre Verwertung," Dr. A. Schmauss; Nr. 6. "Der Erziehungswert der Geologie und ihre Stellung in der Schulorganisation," Prof. Dr. Johannes Walther; "Bildungs und Erziehungswert des erdkundlichen Unterrichts an den höheren Schulen," Prof. Dr. A. Geistbeck; "Ueber den Bildungswert des zoologischen Unterrichts," Bastian Schmid; "Neue Vorschläge für den Anschauungsunterricht unter Verwendung Kinematographischer Bilderserien," Ingenieur Theodor Schopper; "Zur Darstellung des regelmässigen Ikosaeders in schiefer Parallelprojektion," Dr. Ph. Lötzbeyer; "Einige interessante Formeln für das Volumen des regelmässigen Ikosaeders; Dr. Ph. Lötzbeyer.

Zeitschrift für den Physikalischen und Chemischen Unterricht for July; *Prof. Dr. F. Paske, Berlin-Dahlem; Friedbergstrasse 5; 6 numbers, $2.88; M. 12 per year:* "Neuere Anordnungen von Versuchen aus der Wärmelehre," J. Precht; "Ein einfaches Goniometer für Schülerübungen," K. Schütt; "Apparate zur Demonstration von physikalischen Vorgängen am menschlichen Körper," H. Lohmann; "Durchlässige Gitter zur Herstellung lichtstarker Interferenzerscheinungen," K. Lichtenecker; "Versuchsanordnung zur Bestimmung des elektrochemischen Äquivalents durch Widerstandsmessung," W. Stephan.

Zeitschrift für Mathematischen und Naturwissenschaftlichen Unterricht for June; *B. G. Teubner, Leipzig; 12 no., 12 M.:* "Die stereographische Projektion und ihre Anwendung auf die Konstruierende Kugelgeometire, Dr. Gg. Heussel; "Eine mathematische Erörterung des optischen Brechungs gesetzes," Dr. Gustav Berkhan; "Die Behandlung der relativen Zahlen im Unterrichte," Prof. Dr. K. Wolletz; "Der Wilsonsche Staz," Joh. Schumacher; "Schriften des Deutschen Ausschusses für den mathematischen und naturwissenschaftlichen Unterricht"; "Zur Geometrographie," edited by K. Hagge. For July: "Ueber die Radien der Berührungskreise des Kreisvierecks," Dr. Ernst Eckhardt; "Verallgemeinerung eines von Herrn M. Linnich behandelten Lehrsatzes," A. Tafelmacher; "Ueber ein einfaches arithmetisches Analogon zu einem Satze von C. Jordan," Hermann Rothe; "Zur Geometrographie," edited by K. Hagge.

THE PLACE OF PLANT AND ANIMAL STUDIES IN A SCIENCE PROGRAM FOR SECONDARY SCHOOLS.

The foregoing is the general topic to be discussed in the biology section at the Des Moines meeting of the Central Association, November 28th. Certain specific propositions suggested for discussion under this general topic are presented herewith:

I. That a course in science should be required of all in the first two years of the high school course.

II. That, to be science in the educational sense, a course must be scientific both as to teaching method and as to the organization of subject matter. No course should be classed as science simply by virtue of the nature of the information imparted. (Certain courses call for special caution in this connection.)

III. A. That, preferably, the course indicated in I should have continuity through grades IX and X.

B. That, if the course can be given in one year onyl, grade X is preferable to grade IX.

C. That double periods are not essential for this course.

D. That human relation to environment should be the primary theme of this course.

E. That the study of organisms and of chemical and physical phenomena directly related to life should have at least three-fifths weight in such a course.

F. That in this course plant studies should precede animal studies, and that the teaching of alternating plant and animal types, and the organization of the biological subect matter primarily on the basis of general principles are not recommended for this course.

G. That the technical use of the term *food* should be restricted to organic substances.

IV. A. That in grades XI and XII various full year electives should be offered, and that such electives should presuppose the course indicated above.

B. That, when possible, differentiation should be made in these upper courses between those taken by students expecting to go to college and those taken by students not expecting to go to college.

C. That the "college" courses should be administratively equivalent to the similar courses given at colleges, and that college credit should be obtained therefore.

D. That the "non-college" courses of this group should have vocational character, agriculture and domestic science being characteristic thereof.

JOHN G. COULTER, *Bloomington, Ill.,*
Chairman of Biology Section.

NO MORE FREE COPIES OF GOVERNMENT FOOD AND DIET CHARTS.

Owing to a misunderstanding on the part of principals and teachers of schools, the United States Department of Agriculture is receiving many requests for free copies of the large colored food and diet charts issued by the Division of Food Investigations of the Office of Experiment Stations. The Department's supply of copies for free distribution has long been exhausted. These sets of fifteen large colored charts can be obtained only by sending $1.00 in currency or money order to the Superintendent of Documents, Govern-

ment Printing Office, Washington, D. C. These charts which are twenty-one by twenty-seven inches in size and handsomely printed in several colors on a good quality of paper, make excellent wall decorations for the school room. They picture many common foods, such as meat, fish, vegetables, and show graphically the proportions of the various nutritive constituents and waste in them. By this means they give students a practical idea of the food value to various standard articles of diet. No requests for these charts can be filled unless the money is sent with the order to the Superintendent of Documents.

There is general misunderstanding among teachers as to the methods under which they can obtain free of cost the various bulletins issued by the Department of Agriculture. Each Senator and Representative is allotted a number of copies for distribution to his constituents, and to supply requests direct to him. The Department of Agriculture also receives a certain number from each issue to distribute free on application. After the Department's supply is exhausted, it can fill no more requests and applicants must then buy these documents at cost from the Superintendent of Documents, Government Printing Office, unless their Congressman can supply them with free copies from his quota. A letter addressed to the "Division of Publications, U. S. Department of Agriculture, Washington, D. C.," making such a request, will bring lists of documents which can be obtained free, as long as the supply lasts, and also a price list showing cost price of reprinted bulletins which can be obtained from the Superintendent of Documents.

CAMBRIDGE BOTANICAL SUPPLY CO.

The Cambridge Botanical Supply Co. of Waverly, Mass., have recently issued a new sectional catalogue of their scientific apparatus and laboratory equipment. It consists of five parts, Botanical, Biological, Physical, Chemical and Lantern and Microscopical Slides.

The matter is splendidly arranged for easy reference; with the use of the complete index any article listed can be readily found. Many of the articles which this firm puts on the market are illustrated by well executed drawings. This enables one to get a good idea of the apparatus without actually seeing it. They make an exceptionally fine line of Physiological Instruments for use in the botany laboratory. Teachers wishing special apparatus constructed after their own ideas and drawings will find that this firm will give the very best of satisfaction. In this new catalogue one finds that the articles which are illustrated have the description given on the same page. This is a mighty handy and convenient arrangement.

The type is clear and large, making the catalogue one easy to read. The paragraphs are all open, making it easy for one to get at just what he wants in the descriptions which are written in a clear and concise style.

The long experience in business which this firm has had enables them to know pretty well what their customers want. From their stock they are able to promptly fill all orders. All science teachers in the country should possess a copy of their catalogue for reference before ordering apparatus or supplies.

The firm is noted for its courteous treatment of all its customers.

BOOKS RECEIVED.

Handbook of Physiology, by W. D. Halliburton, King's College, London. Pages xix+923. 600 illustrations. 16x22.5 cm. Cloth. 1913. $3.00 net. P. Blakiston's Son and Company, Philadelphia.

Farm Arithmetic, by Charles W. Burkett, Editor American Agriculturist and Karl D. Swadzel, Ohio State University. Pages xiii+280. 13x19 cm. Cloth. 1913. Orange Judd Company, New York.

Science for the Fifth Grade, by Percy E. Powell, Berkeley, Cal. Pages xvi+198. 13x19 cm. Cloth. 1913. 60 cents. The A-to-Zed School, Berkeley, California.

An Illustrated Flora of the Northern United States, Canada and the British Possessions, by Nathaniel L. Britton, Columbia University, and Hon. Addison Brown, New York Botanical Garden. In three volumes. Pages xxix+2052. 19x27.5 cm. Cloth. 1913. Charles Scribner's Sons, New York.

Backward and Feeble-Minded Children, by Edmund B. Huey, Johns Hopkins University. Pages xv+221. 13.5x20 cm. Cloth. 1913. $1.40.

School Algebra, by David Eugene Smith and George Wentworth. Pages iv+298. 13.5x19 cm. Cloth. 1913. 90 cents. Ginn and Company, Boston.

The Teaching of Arithmetic, by David Eugene Smith, Teachers College, Columbia University. Pages v+196. Illustrated. 13x19. Cloth. 1913. $1.00. Ginn and Company, Boston.

Entomology with Special Reference to Its Biological and Economic Aspects, by Justus W. Folsom, University of Illinois. Pages vii+402. 300+ illustrations. 16x23 cm. Cloth. 1913. $2.25 net. P. Blakiston's Son and Company, Philadelphia.

The Chemistry of Plant and Animal Life, by Harry Snyder, University of Minnesota. Pages xxii+388. 13x19.5 cm. Cloth. 1913. $1.50. The Macmillan Company, New York.

Stories of Old Greece and Rome, by Emilie Kip Baker. Pages xii+382. 13.5x19.5 cm. Cloth. 1913. $1.50. The Macmillan Company, New York.

An experimental Course in Alternating Currents, by Elmer E. Burns, Medill High School, Chicago. Pages xiv+101. 12.5x18.5. Paper. 1913. Joseph G. Branch Publishing Company, Chicago.

Shop Mathematics. Part II. Advanced Shop Mathematics, by Earle B. Norris and Ralph T. Craigo, University of Wisconsin. Pages xi+214. 16x24 cm. Cloth. 1913. $1.50 net. McGraw-Hill Book Company, New York.

Trigonometry, by Alfred M. Kenyon, Purdue University, and Louis Ingold, University of Missouri. Pages xi+132+xviii+124. 13x20 cm. Cloth. 1913. $1.35 net. The Macmillan Company, New York.

Principles and Methods of Teaching Geography, by Frederick L. Holtz, Brooklyn Training School. Pages xii+359. 13.5x19.5 cm. Cloth. 1913. $1.10.

Shelter and clothing, by Helen Kinne and Anna M. Codey, Columbia University. Pages xv+377. 13.5x19 cm. Cloth. 1913. $1.10.

The Pupils Arithmetic, by James C. Byrnes, Julia Bichman and John S. Roberts, New York City Schools. Pages ix+432+ix. 13x19.5 cm. Cloth. 1913. 60 cents.

Botany for Secondary Schools, by L. H. Bailey. Pages xiv+465. 13x19.5 cm. Cloth. 1913. $1.25.

Animal Husbandry for Schools, by Merritt W. Harper, Cornell University. Pages xxiv+409. 152 illustrations. 13x19.5 cm. Cloth. 1913. $1.40 net. The Macmillan Company, New York.

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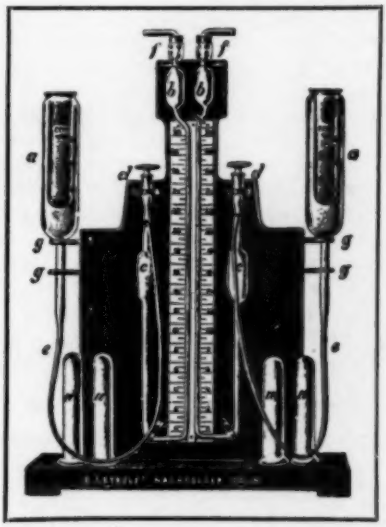

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Plane Geometry, by Walter B. Ford, University of Michigan, and Charles Ammerman, McKinley High School, St. Louis. Pages ix+213+xxxi. 13x19 cm. Cloth. 1913. 80 cents. The Macmillan Company, New York.

How I Kept My Baby Well, by Anna G. Noyes. 193 pages. Illustrated. 13x20 cm. Cloth. 1913. $1.25.

Inductive Versus Deductive Methods of Teaching: An Experimental Research, by W. H. Winch, 146 pages. 13x20 cm. Cloth. 1913. $1.25. Warwick and York, Baltimore.

BOOK REVIEWS.

An Experimental Course in Alternating Currents for Vocational Work in Electricity, by Elmer E. Burns, Medill High School, Chicago. Pages xiv+101. 13x18.5 cm. Paper, 1913.

Any instructor proposing to start a course in laboratory alternating currents cannot do better than adopt this book as a guide. It is written by a man thoroughly familiar with both the practical and theoretical side of electricity. The aim of the book fundamentally is to make the subject simple and as clear as possible, by teaching connectedly the principles upon which alternating currents are generated and then by actual work in the laboratory with this phase of electricity. To understand the subject matter one should have a good knowledge of high school physics. There are forty experiments selected for the fundamental principles they teach as well as for their practical applications. There are forty-three drawings. The book deserves a wide use. C. H. S.

The Pupils' Arithmetic. Book Six. The Complete Arithmetic, by James C. Byrnes, Member of Board of Examiners, Department of Education, Julia Richman, Late District Superintendent of Schools, and John L. Roberts, District Superintendent of Schools, New York. Pages viii+432. 13x19 cm. 60 cents. 1913. The Macmillan Company, New York.

This *Complete Arithmetic* is designed for the grammar grades and gives special emphasis to the work of the last two years. The fundamental rules, common fractions, and decimals are treated with sufficient detail for review work, but the remaining topics are treated with a completeness suitable for a first presentation. The use of equations and the formulas of mensuration serve as a good introduction to algebraic work. The book seems to be modern in theory and practice. The problems are related to the experiences and to the future work of the pupils, and they conform to present-day commercial practice. The type is large and clear and the pages are not crowded. Altogether it appears to be an excellent book. H. E. C.

Manual of Qualitative Analysis, Reagent and Combustion Methods, by W. F. Hoyt. 36 pages. 1913. 30 cents. The Macmillian Company, New York.

This little book is a most excellent manual for use in high school chemistry classes. A great many chemistry teachers devote the latter part of the year's work to simple tests of unknowns, since these tests familiarize the students with properties, reactions and tests for the various elements and reagents and also the fundamental processes of chemistry and the principles of volume as nothing else can. In addition to the usual method it devotes five pages to an analytical table for testing solids by the "Dry" method. Eleven simple tests are given for testing drinking water. Two pages of directions for making solutions are given. C. M. T.

The authors of "Practical Botany," described below, have in preparation and soon to be published "Introduction to Botany," giving a distinctly elementary presentation—for a half-year course in high schools—of those features of plant life which are of educational, aesthetic, and economic interest to all people. The style is simple and direct and the point of view that of the uninformed beginning student.

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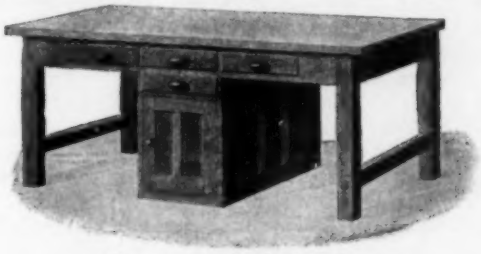

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Everyday English, Book Two, by Franklin T. Baker, Teachers College, Columbia University and Ashley H. Thorndike, Columbia University. Pages xv+336. 14x19 cm. Cloth, 1913. 60 cents net. The Macmillan Company, New York.

What a pity that books of this high character containing such a splendid method of treating a subject not to easy, did not come into the arena of English teaching long before the present time! Too many books on English grammar have been written in harmony with the high ideals of their authors but wholly beyond the comprehension of the pupils for whom the book was intended. Its treatment in this text will not tend to drive the pupil from, but rather draw him to it.

Part one of the book consists of a delightful and comprehensive treatise of English grammar, it being presented in a most charming, clear and simple manner. It is free from all of those subtleties and complications which cause pupils to dislike grammar and contains all the grammar that is necessary for everyday English. The sentence has been made the center around which the framework of the discussion is built. Illustrative sentences have been chosen not only from the best literature but also from common everyday speech.

Part two is devoted expressly to a study of composition, both oral and written. More emphasis, however, being placed on the former than the latter, as this is the normal order of study.

The mechanical work represents perfection in the art of book making. The type is right and the arrangement of material is splendid. The book will doubtless have an extensive adoption. C. H. S.

A Manual of Zoölogy, by Richard Hertwig, Professor of Zoölogy in the University of Munich, Third American, from the Ninth German Edition, translated and edited by J. S. Kingsley, Professor of Zoölogy in Tufts College. Pages xi+606. 1912. Henry Holt and Company, New York.

Little need be said of this book, for the author and translator needs no introduction to students of zoölogy and former editions of the work are familiar to us. Nevertheless it should be said again that the book is an authority which should be in every zoölogy student's library. The translator has done more than translate, he has edited the German work to adapt it to the needs of the American student. The size has been reduced without impairing the value by putting part of the matter in smaller type and by eliminating "unnecessary words and phrases" and "omitting some matter of minor importance." W. W.

The Golden Deed Book, a School Reader by E. H. Sneath, Yale University, George Hodges, Cambridge, and E. L. Stevens, Associate Superintendent of Schools, New York City. Pages xiii+351. 13x19.5 cm. Cloth. 1913. 55 cents net. The Macmillan Company, New York.

The keynote has certainly been struck, in this, the sixth of the Golden Rule Series of school readers. This book embodies a graded system of moral instruction by the indirect method. "It introduces the pupil, in a concrete and interesting manner to the subject matter of morals by means of fairy tale, myth, fable, allegory, parable, legend, stories of real life, of heroes and heroines, biography and historical incident."

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It surely is a splendid reader looked at from every point of view and merits the widest adoption. C. H. S.

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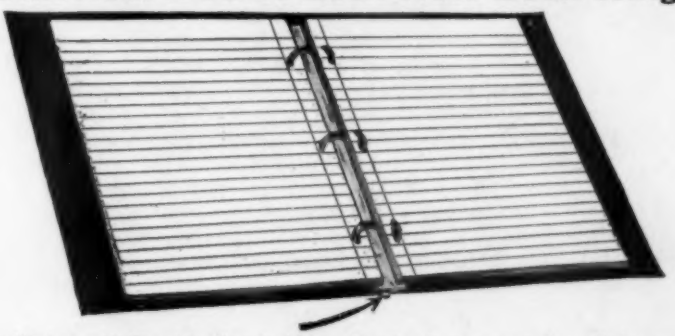

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A Text-Book of Inorganic Chemistry, by D. A. F. Holleman. Issued in English by H. C. Cooper. 4th English edition, completely revised. Total issue, 13,000. 505 pages. 1912. $2.50. John Wiley and Sons, New York.

This edition represents a thorough revision of this well known and world wide used text by the Dutch author and the American translator. It has been entirely rewritten in many of the descriptive portions. One special feature of the book is the use of differential formulae. C. M. T.

Practical Chemistry for Engineering Students, by A. J. Hale. 192 pages. 1912. $1.00. Longmans, Green and Co., New York.

This is a laboratory manual especially written for students in English technical schools and colleges. It contains thirteen chapters. The first ten are devoted to experiments, mostly quantitative, on the nonmetals and their compounds. One chapter gives a scheme, and experiments, for simple qualitative analysis. Chapter twelve contains 14 experiments on volumetric methods. Chapter fourteen devotes 25 pages to various practical tests in quantitative analysis. The appendix has 25 valuable tables. There is a four page index.

This would make an excellent manual for use in our technical high schools. C. M. T.

Advanced Shop Mathematics, by Earle B. Norris, Associate Professor of Mechanical Engineering, and Ralph T. Craigo, Instructor in Mathematics, University of Wisconsin. Pages xi+214. 16x24 cm. $1.50. 1913. McGraw-Hill Book Company, New York.

This volume includes the second half of the instruction papers in Shop Mathematics as worked out and used in the Extension Division of the University of Wisconsin. Practical applications of some of the principles of algebra, geometry, and trigonometry are presented in a way to make the book suitable for home study as well as for use in technical high schools, and trade schools. The first seventy pages deal with formulas and algebraic equations, which are explained and illustrated by the use of shop problems. A good working knowledge of algebra may be obtained from these chapters. Chapters X to XIV deal with the construction and properties of geometric figures. The last six chapters deal with angle functions and give a large number of applications in machine-shop problems.

Throughout the book the explanations are given with much detail and ought to be readily understood by the man who has to dig things out for himself. It is an ideal book for self-instruction, and with Part I gives every shop man who desires it the opportunity of mastering the mathematical problems of his trade. H. E. C.

An Elementary Treatise on Calculus, by William S. Franklin, Barry MacNutt, and Rollin L. Charles of Lehigh University. Pages ix+253. 15x21 cm. 1913. This book has not as yet been placed in the hands of regular publishers, but any one wishing to use the book in class can obtain it from F. R. Ashbaugh, Lehigh University Supply Bureau, South Bethlehem, Pa., at $2.00 per copy, less 16⅔ per cent.

It is to be hoped that this book marks a new era in the teaching of calculus in this country. To the present time most of the work of the student of calculus has been the manipulation of mathematical forms. He has differentiated and integrated all sorts of complicated expressions and learned very little about working real problems. A footnote to an example of the simplest kind of integration may well be quoted to show the point of view of the authors. "If one can get 200 dollars by multiplying two dollars per day by 100 days, one might well ask how to perform such a profitable operation? The answer is: Work hard for 100 days! That is

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what this particular multiplication means. Nearly every mathematical process rightly understood relates to physical reality in a manner as definite and as exacting as this particular case of multiplication."

Throughout the book the underlying principles are developed clearly and concisely and in close relation to their application. Indeed, the problem has the first place always. In order that the continuity of the discussions shall not be broken, the formal problems are put in an appendix. The authors wish to emphasize the incomplete character of the work, and have given in an appendix a list of treatises on mathematics and mathematical physics. With continual reference to these books and the necessary drill in manipulation secured by lists of formal exercises, a year's work in calculus with this book as a basis will fit students to use their calculus whenever occasion for it arises. H. E. C.

Variations in the Grades of High School Pupils, by Clarence T. Gray, University of Texas. 120 pages. 13x20 cm. cloth. 1913. $1.25. Warwick and York, Baltimore.

Only comparatively recently has any attempt been made to study scientifically the relative merits of the many systems of grading pupils in any phase of work. This monograph gives the results of the author's investigations into the causes of the variations of grading of high school pupils. The results are clearly set forth; he shows how unreliable are the grades commonly given by teachers. There are 47 graphs or diagrams and 35 tables included in the work. The book will be of much help to principals in enabling them to correct any faults in grading which may exist in their schools. C. H. S.

Chemistry and its Relation to Daily Life. A textbook for Students of Agriculture and Home Economics in Secondary Schools, by Louis Kahlenberg and E. B. Hart. 392 pages. 1913. $1.25. The Macmillan Company, New York.

Although primarily intended for use by students of agriculture and home economics this book could very profitably be used in any secondary school chemistry class. It contains much valuable information on subjects that interest every person. It is written in such a pleasing style that persons who know nothing about chemistry can easily understand the subject discussed.

The first eight chapters are devoted to the nonmetallic elements. Two chapters are given to the methods of the alkalies and the alkaline earths and alumina and various other metals. Ten chapters treat of the following topics: Paints, oils and varnishes; leather and articles from which wearing apparel is made; the soil; fertilizers and farm manure; plant life; human and animal foods; milk and its products; poisons for farm and orchard pests. The last chapter contains 150 experiments that are intended to be made along with the study of the text.

At the end of each chapter is a well selected test of questions on the subject matter of the chapter.

It is a most valuable book and should have a large use. C. M. T.

Elementary Experimental Chemistry, by F. E. Weston. 140 pages. 1911. Longmans, Green and Company, New York.

Although this is an English laboratory manual, it is just as well adapted for use in American high schools. The experiments are well selected and well written. The results of each experiment are summed up in brief, concise "conclusions," so that the student knows definitely what results to expect. He thus can work more intelligently. There are 78 illustrations taken from photographs of actual apparatus and laboratory operations. It contains a four page index. C. M. T.